

REPLACEMENT of BRIDGE 145/116

STATE PROJECT 16236 US ROUTE 4 OVER BUNKER CREEK

DURHAM, NEW HAMPSHIRE



Hydraulic & Scour Analysis

November 2017

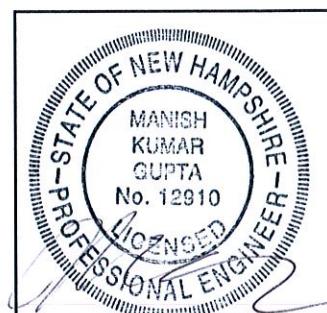


GM2 Associates, Inc.

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Executive Summary

GM2 Associates has been retained by the New Hampshire Department of Transportation to provide preliminary design for the replacement of the existing bridge carrying U.S. Route 4 (a.k.a. Piscataqua Road) over Bunker Creek. Bunker Creek is a portion of the Great Bay Estuary system and discharges to the Oyster River just south of the bridge location. The Oyster River is one of seven major rivers that are tributary to the estuary (See Figure 1). The existing bridge is located at the east end of a causeway crossing the tidal wetlands and the tidally influenced Bunker Creek. The purpose of this section is to evaluate the hydraulic effects of the proposed bridge replacement and provide preliminary computations relative to expected scour.

The proposed project involves replacing the existing bridge with a new structure. The proposed bridge will increase the hydraulic opening of the structure. The existing bridge provides a $15' \pm$ opening. Rehabilitation of the existing bridge is not a viable option given its condition and size.

The new bridge is a 76' bridge replacement which will provide a 73' wide clear span opening with sloped embankments and setback stub abutments founded on deep pile foundations. The proposed wing walls are perpendicular to the roadway (90 degree wing walls).

The road surface profile will be raised as much as four feet at the bridge with the road way sag shifted approximately 300 feet to the west of the bridge. This will move any possible weir flow conditions away from the bridge.

This hydraulic analysis evaluates the performance of the proposed replacement structure using a design flow rate modified from the original Hydrologic Analysis provided by McFarland-Johnson, Inc. in 1998. This reach of Bunker Creek has not been studied in detail by FEMA in support of the local Flood Insurance Study (FIS). A USGS StreamStats regression analysis was also conducted for the project.

The results of the Hydraulic Analysis documented herein indicate that the Bunker Creek flood flows of any size are too small to have any effect on the proposed Route 4 crossing. High level water surface elevations are dictated by the tide and storm surge elevations.

The results presented in this report have also been applied to the Scour Analysis provided herein. The scour evaluation will determine the magnitude of scour potential at this crossing for the proposed bridge and be considered in the foundation design for unbraced length.

All elevations associated with the preliminary hydraulic analysis of the bridge are referenced to the **NAVD 1988** vertical datum.

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Project Description

GM2 Associates, Inc. has been retained to provide preliminary design services for the design/build replacement project for the US Route 4 Bridge over Bunker Creek. The structure is located at the east end of a causeway crossing the tidal wetlands and the Bunker Creek. Bunker Creek discharges into the Oyster River immediately south of the bridge location.

The project consists of replacing the existing 15 foot long, 30 foot wide single span structure built in 1933. The existing bridge is comprised of a reinforced concrete deck slab, concrete abutments and footings founded on timber piles.

The replacement is a 76' long bridge which will provide a 73' wide clear span opening with sloped embankments and setback stub abutments founded on deep pile foundations and 90 degree perpendicular wing walls.



Figure 1: Project Location on USGS Quadrangle Map

Hydraulic and Scour Report Bridge 145/116



Figure 2: Project Location on Google Earth

The bridge has a zero degree skew, on a horizontal tangent and an approximate 3% grade section of US Rte. 4. The existing roadway is approximately 30 feet wide and is not illuminated through the project area.

Bunker Creek flows in a general north to south direction at the bridge, has a drainage area of only 0.57 square miles and is a locally anabranched watercourse to the bridge. Due to the causeway, there are very few buildings located in the vicinity of the US Route 4 crossing.

Hydrology and Tidal Storm Surge

The flood events investigated include the 2-, 10-, 25-, 50-, 100-, and 500-year riverine flows for the 0.57 square mile drainage area. Discharges associated with each of these return periods were based on the results from the USGS StreamStats regression equation calculator. Documentation of the StreamStats output can be found in the Appendix B. The following table documents the results of the hydrologic analysis.

	Q-10	Q-50	Q-100	Q-500
StreamStats	57.3 cfs	100 cfs	125 cfs	187 cfs
SCS TR-20		390 cfs	490 cfs	
Design			200 cfs	300 cfcfs

McFarland-Johnson, Inc. (MJ) performed a TR-20 analysis of Bunker Creek in 1988 for the 50-year and 100-year storm events. The MJ report considers the results conservatively high to the amount of three to four times for the drainage area.

As a conservative compromise for design, the Q-100 value of 200 cfs will be used.

In order to model the amplitude of the tidal storm surge, tidal elevations recorded during Storm Sandy in October of 2012 were reviewed. A report titled ***Monitoring Storm Tide and Flooding from Hurricane Sandy Along the Atlantic Coast of the United States, October 2012***, dated 2013 by the USGS, recorded a peak tide elevation of 7.19' at a temporary tide station installed in Hampton, NH, near Hampton Beach State Park. Another report titled ***NOAA Water Level and Meteorological Data Report, Hurricane Sandy***, dated January 24, 2013 by NOAA, reported peak storm surge elevations at the Fort Point (Portsmouth, NH) tide station of 6.41', with a residual elevation (delta of predicted vs. observed elevation) of 1.86'. Based on these reports, a two-foot high storm surge was applied to the spring tide condition for the purposes of modeling a storm event.

Making surge elevation adjustments upstream to the project area and calibrating to the observed Storm Sandy elevation, the Peak Storm Surge water surface elevation is estimated to be 6.57 feet.

Hydraulic Analysis

Water surface profiles were developed for Bunker Creek in the vicinity of Bridge No. 145/116 carrying US Route 4. These profiles were developed for the proposed alternate as defined by the Preliminary Engineering Report. All water surface profiles were developed using the Army Corps of Engineers (USACE) HEC-RAS program (version 5.0.3).

Model Geometry and Hydraulic Parameters

Bunker Creek, in the vicinity of Bridge No. 145/116, has a watershed area of 0.57 square miles, classifying the creek as a Tier 2 watercourse. The US Route 4 Major Roadway classification requires that the bridge be designed to pass a discharge equal to the one percent recurrence interval storm event (100-year flood) with low chord under clearance of not less than 1 foot.

Hydraulic and Scour Report Bridge 145/116

Existing channel and bridge geometry for the hydraulic model was obtained from field survey. All elevations are referenced to the NAVD 1988 datum.

This reach of Bunker Creek can be characterized as having a flat slope (0.2%) for the 300+ foot study reach.

Upstream of the structure the flow area is broad, vegetated and locally anabranching. The banks of the anabranching flow area are tree lined and rise sharply, providing minimal overbank storage.



Downstream of the structure, the creek flows immediately into the Oyster River which controls the Starting Water Surface Elevation (SWSEL) for the hydraulic model. The highest water surface elevations are functions of the degree of tide and storm surge. The high tide storm surge elevation is at 6.57 feet.

Channel and overbank roughness (Manning's 'n' values) were assigned based on site inspection. The channel and overbank roughness coefficients used in the hydraulic model are as follows:

Upstream Overbanks	0.08
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Hydraulic and Scour Report Bridge 145/116

Upstream Vegetated, Anabranch	0.06
Channel proper	0.035
Downstream Overbanks	0.03-0.06

Table 1 – Roughness Coefficients

Normal depth starting water surface elevation (SWSEL) was used for the riverine design flow rate with low tail water conditions. The storm surge depth was used for maximum tail water conditions.

The location and extent of the hydraulic cross sections are represented in the plan below.

There is virtually no difference in the Computed Water Surface Elevation (CWSEL) from the Oyster River tidal elevation and the anabranch reach elevation upstream of US Route 4. The bridge is just a flow balancing structure between up and downstream.

Existing Conditions

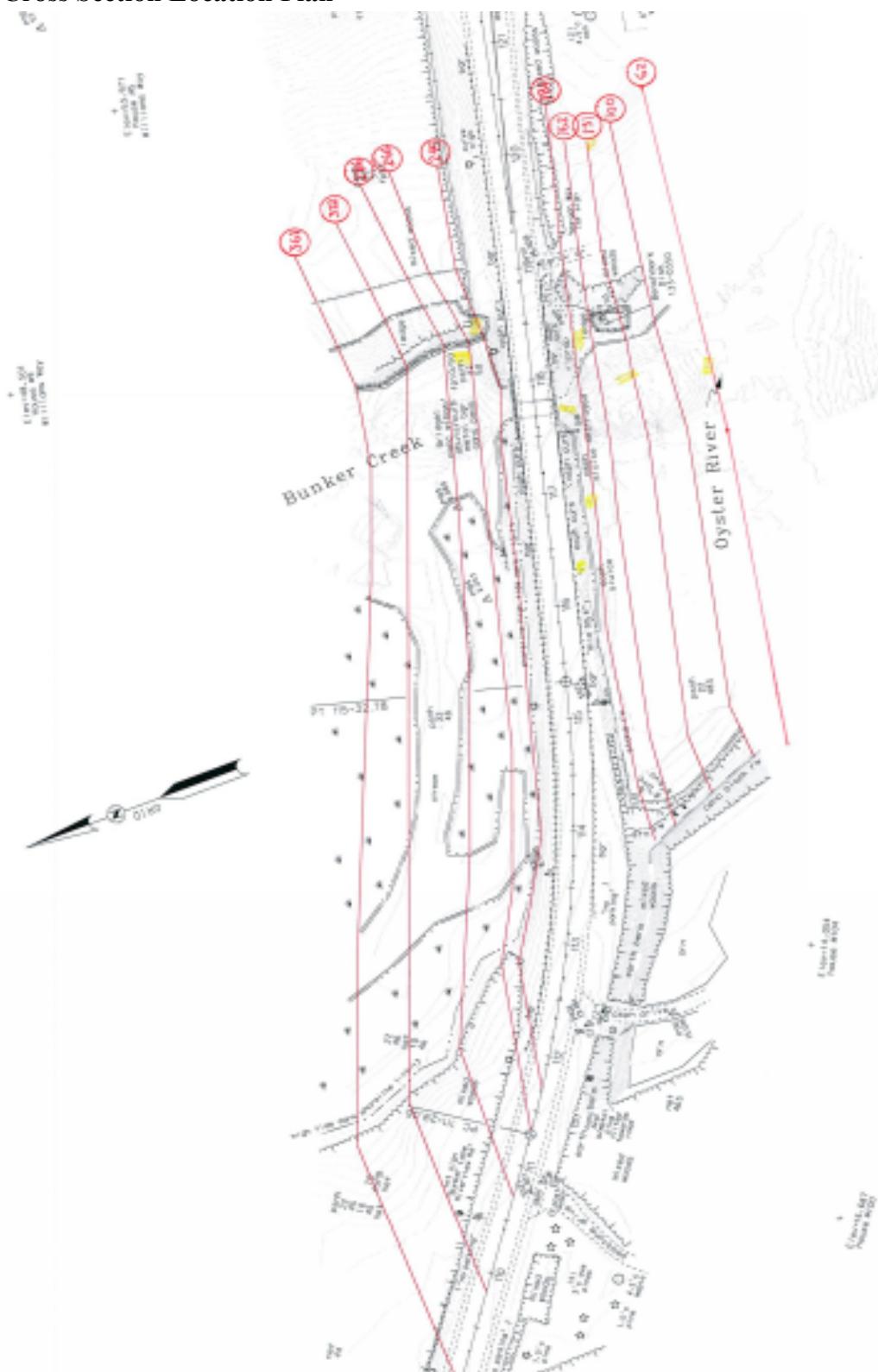
The existing bridge was built in 1933. It is not currently listed on the Department's Red List, but has required recent repairs. The deck, superstructure, and substructure are listed in satisfactory condition according to the June 5, 2012, bridge inspection report. The superstructure consists of a cast-in-place concrete slab. According to the existing bridge plans, the substructure consists of spread footings founded on timber piles. The clear span is 15 feet and the rail-to-rail width is 30 feet. The bridge is on the Department's 10 Year Plan for replacement.

Proposed Condition

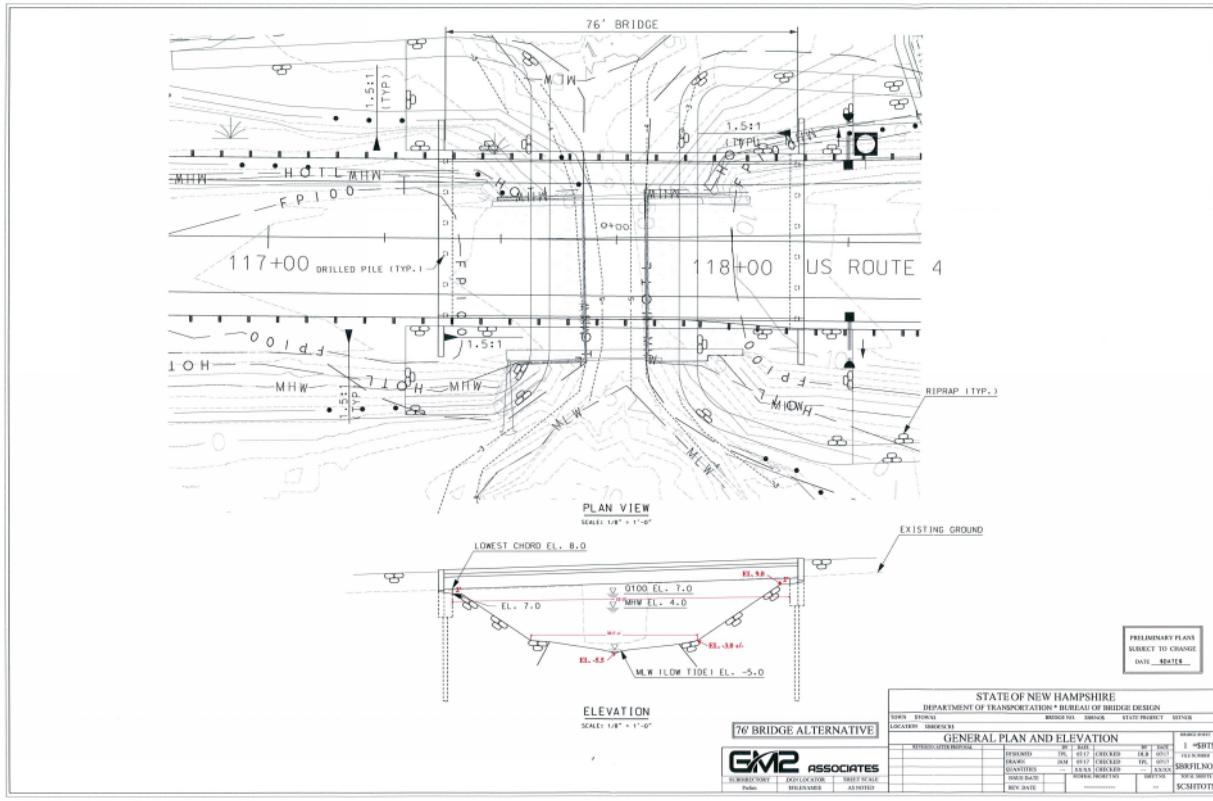
The proposed conditions model was created directly from a topographic and structure location survey prepared for this project. Section locations were selected and surveyed in an attempt to represent all major stream features through this reach of Bunker Creek. This included all major changes in expansion and contraction sections, areas of material or land cover changes, and other areas determined to be hydraulically relevant during the site visit. The two bridge bounding sections (at the up and downstream toes of the roadway embankment) were surveyed without including the roadway embankments. The bridge and roadway geometry is included in the bridge editor.

The modeled proposed bridge is a 76' bridge replacement which will provide a 73' wide clear span opening with sloped embankments and setback stub abutments founded on deep pile foundations. The proposed wing walls are perpendicular to the roadway (90 degree wing walls).

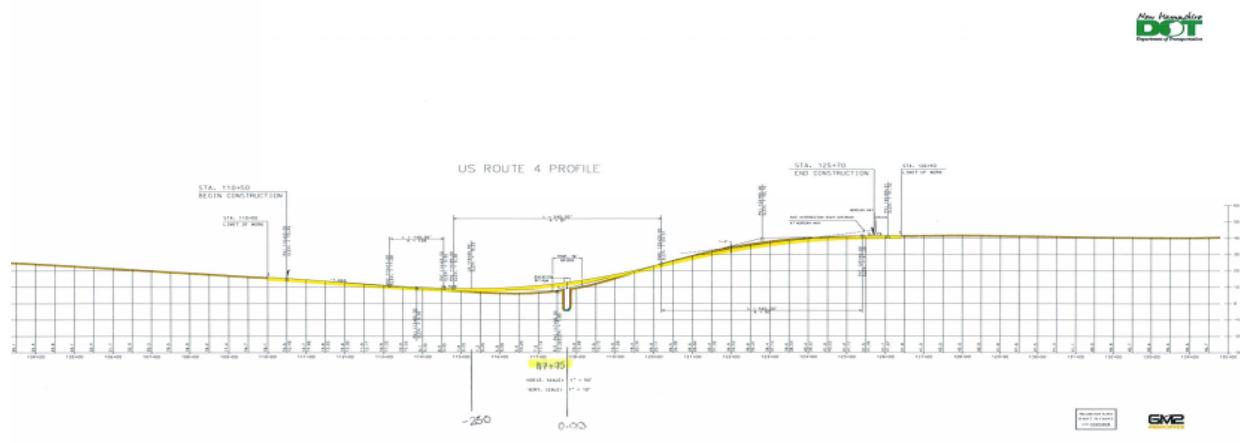
Hydraulic and Scour Report Bridge 145/116
Cross Section Location Plan



General Plan and Elevation



The road surface profile will be raised as much as four feet at the bridge with the road way sag shifted approximately 300 feet to the west of the bridge. This will move any possible weir flow conditions away from the bridge.



Road Surface Profile

Results

Water Surface Profile Plots

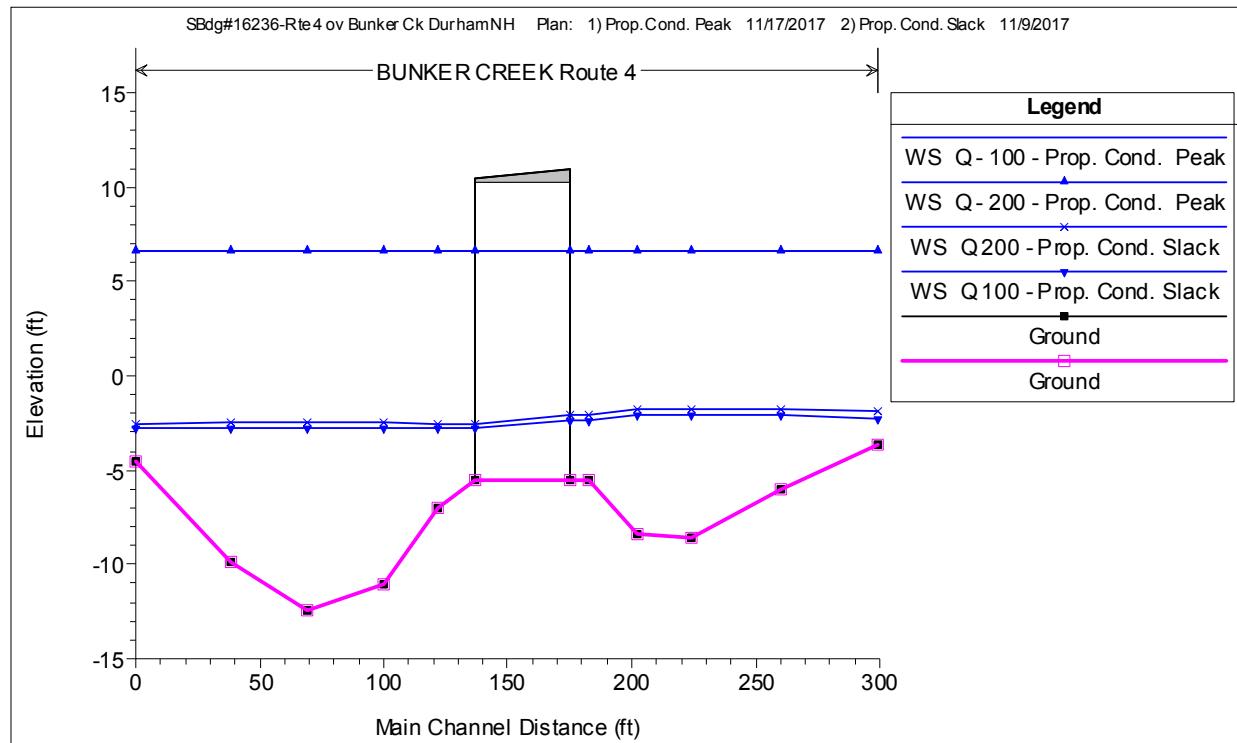


Figure 1 – 100-year Peak Storm and Slack Tide Events at Design Discharge

Comparison Tables

River Station	Q100 Nat Slack Tide W.S. (ft)	Q100 Nat Storm Tide W.S. (ft)	Q100 Prop Slack Tide W.S. (ft)	Q500 Prop Slack Tide W.S. (ft)	Q100 Prop Storm Tide W.S. (ft)	Q500 Prop Storm Tide W.S. (ft)
361	-2.10	6.57	-2.24	-1.64	6.57	6.58
322	-2.00	6.57	-2.07	-1.58	6.57	6.58
286	-1.99	6.57	-2.07	-1.57	6.57	6.58
264	-2.00	6.57	-2.07	-1.58	6.57	6.58
245	-2.52	6.57	-2.33	-1.86	6.57	6.57
210	US Route 4 Bridge					
184	-2.65	6.57	-2.79	-2.42	6.57	6.57
162	-2.59	6.57	-2.72	-2.31	6.57	6.57
131	-2.59	6.57	-2.72	-2.31	6.57	6.57
100	-2.59	6.57	-2.72	-2.31	6.57	6.57

Hydraulic and Scour Report Bridge 145/116

62	-2.63	6.57	-2.77	-2.38	6.57	6.57
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Q100 and Q500 Water Surface Elevations

River Station	Q100 Nat Slack Tide (ft/sec)	Q100 Nat Storm Tide (ft/sec)	Q100 Prop Slack Tide (ft/sec)	Q500 Prop Slack Tide (ft/sec)	Q100 Prop Storm Tide (ft/sec)	Q500 Prop Storm Tide (ft/sec)
361	3.60	0.09	4.38	3.12	0.09	0.13
322	1.06	0.08	1.09	1.31	0.08	0.13
286	0.71	0.08	0.72	0.95	0.08	0.13
264	0.83	0.11	0.85	1.11	0.11	0.16
245	5.11	0.11	3.63	3.81	0.28	0.42
210	US Route 4 Bridge					
184	2.83	0.22	3.05	3.78	0.29	0.44
162	0.55	0.10	0.57	0.78	0.07	0.11
131	0.40	0.09	0.41	0.57	0.07	0.10
100	0.46	0.09	0.47	0.65	0.07	0.10
62	1.64	0.09	1.82	2.06	0.07	0.11

Q100 and Q500 Velocities

Conclusions and Recommendations

From a hydraulic perspective, the proposed replacement bridge will meet all hydraulic requirements of the site.

Scour Analysis

Executive Summary

US Route 4 is a major state road in the Town of Durham, New Hampshire. Bridge No. 145/116 carries US Route 4 over Bunker Creek.

Bunker Creek is a portion of the Great Bay Estuary system and discharges to the Oyster River just south of the bridge location. The Oyster River is one of seven major rivers that are tributary to the estuary. The existing bridge is located at the east end of a causeway crossing the tidal wetlands and the tidally influenced Bunker Creek.

The new bridge is a 76' bridge replacement which will provide a 73' wide clear span opening with sloped embankments and setback stub abutments founded on deep pile foundations.

EXECUTIVE SUMMARY TABLE

BRIDGE NO 145/116

Recommended NBIS Rating Item 113		8
Recommended NBIS Rating Item 71		9
Recommended NBIS Rating Item 61		9
Results	Stable for Calculated Condition	
Depth of Scour	200-yr	2.83 feet
On-Off System		On
Planned Action		Routine Inspection
Analyzed/Assessed		Analyzed
Foundation		Deep Piles to Bedrock

Utilizing the methodologies outlined in HEC-18, the following results were obtained:

	200-year Slack Tide	200-year Storm Surge
Contraction Scour (Horizontal)	2.53.	0.00
Contraction Scour (Vertical)	N/A	N/A
Abutment Scour		
Left	0.30	0.94
Right	0.27	1.49
Maximum Scour Depths	2.83	1.49

Component scour depths for Bridge No. 145/116

With the minimal depth of total scour for the proposed bridge and the distance to the setback stub abutments, there is no scour issue at the site and the bridge should be Rated NBIS 113 = 8.

Appendix A

Site Photos

Bunker Creek, Durham NH

Bunker Creek Upstream

Legend



Google Earth

© 2017 Google

N

6.64 ft

Bunker Creek, Durham NH

Bunker Creek Downstream to Oyster River Downstream

Legend



N
V

Google Earth

© 2017 Google

7.27 ft

Bdg #16236, Rte 4 Durham NH

Bunker Creek Downstream to Oyster River Upstream

Legend



Google Earth

© 2017 Google

N
E
S
W

6.54 ft

Bdg #16236, Rte 4 Durham NH

Rte 4 view looking west

Legend



Google Earth

© 2017 Google



5.46 ft

Appendix B

HEC-RAS Model I/O Data and Cross Section Plots

16236_PerlimDes_20ct17.rep

HEC-RAS HEC-RAS 5.0.3 September 2016
U.S. Army Corps of Engineers
Hydrologic Engineering Center
609 Second Street
Davis, California

X	X	XXXXXX	XXXX	XXXX	XX	XXXX
X	X	X	X X	X X	X X	X
X	X	X	X	X X	X X	X
XXXXXXX	XXXX	X	XXX	XXXX	XXXXXX	XXXX
X	X	X	X	X X	X X	X
X	X	X	X X	X X	X X	X
X	X	XXXXXX	XXXX	X X	X X	XXXXX

PROJECT DATA

Project Title: SBdg#16236-Rte 4 ov Bunker Ck Durham NH

Project File : 16236_PerlimDes_20ct17.prj

Run Date and Time: 11/22/2017 11:44:28 AM

Project in English units

PLAN DATA

Plan Title: Proposed Cond. Peak Tide

Plan File : t:\Projects\New Hampshire\Durham_16236\16236 - Part A\Computations\Hydraulics\1D HEC-RAS model\16236_PerlimDes_20ct17.p02

Geometry Title: Bunker Creek Proposed Condition

Geometry File : t:\Projects\New Hampshire\Durham_16236\16236 - Part A\Computations\Hydraulics\1D HEC-RAS model\16236_PerlimDes_20ct17.g02

Flow Title : Riverine with Storm Surge

Flow File : t:\Projects\New Hampshire\Durham_16236\16236 - Part A\Computations\Hydraulics\1D HEC-RAS model\16236_PerlimDes_20ct17.f01

Plan Summary Information:

Number of: Cross Sections = 10 Multiple Openings = 0
 Culverts = 0 Inline Structures = 0
 Bridges = 1 Lateral Structures = 0

Computational Information

Water surface calculation tolerance = 0.01
Critical depth calculation tolerance = 0.01
Maximum number of iterations = 20
Maximum difference tolerance = 0.3
Flow tolerance factor = 0.001

Computation Options

Critical depth computed only where necessary

Conveyance Calculation Method: At breaks in n values only

Friction Slope Method: Average Conveyance

Computational Flow Regime: Subcritical Flow

16236_PerlimDes_20ct17.rep

FLOW DATA

Flow Title: Riverine with Storm Surge

Flow File : t:\Projects\New Hampshire\Durham_16236\16236 - Part A\Computations\Hydraulics\1D HEC-RAS model\16236_PerlimDes_20ct17.f01

Flow Data (cfs)

River Q 500	Reach	RS	Q 100	Q 200
BUNKER CREEK 300	Route 4	361	200	250

Boundary Conditions

River Downstream	Reach	Profile	Upstream
BUNKER CREEK Known WS = 6.57	Route 4	Q 100	
BUNKER CREEK Known WS = 6.57	Route 4	Q 200	
BUNKER CREEK Known WS = 6.57	Route 4	Q 500	

GEOMETRY DATA

Geometry Title: Bunker Creek Proposed Condition

Geometry File : t:\Projects\New Hampshire\Durham_16236\16236 - Part A\Computations\Hydraulics\1D HEC-RAS model\16236_PerlimDes_20ct17.g02

CROSS SECTION

RIVER: BUNKER CREEK

REACH: Route 4 RS: 361

INPUT

Description: Last upstream river section

Station	Elevation	Data num=	59	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
-195.13	20.23	-193.28		20	-181.41	19	-169.23	18	-157.05	17	
-137.11	16	-124.63		15	-102.74	14	-99.39	13	-96.68	12	
-93.16	11	-89.64		10	-86.13	9	-82.61	8	-79.09	7	
-75.58	6	-72.06		5	-68.54	4	-64.5	3	-60.36	2	
-56.21	1	-49.57		0	-42.11	-1	-30.72	-2	-20.99	-3	
-10.74	-3	0	-3.64	10.98	-3	49.38	-2	61.88	-1.22		
69.42	-2	93.72		-2	104.87	-1	106.21	-2	107.42	-3	
110.06	-2	112.44		-1	114.46	-0.02	559.43	1.24	569.4	2	
586.94	3	593.39		4	598.84	5	613.51	6	622.86	7	
634.88	8	649.37		9	661.35	10	671.18	11	680.75	12	
703.65	13	751.63		14	793.18	14	808.85	15	813.1	15	
816.59	15	821.32		16	827.45	17	835.7	17.45			

16236_PerlimDes_20ct17.rep

Manning's n values	Sta	n Val	Sta	num=	5						
-195.13	.08	-60.36		n Val	.06	-30.72	Sta	n Val	.035	Sta	n Val
Bank Sta:	Left	Right		Lengths:	Left	Channel	Right			Coeff	Contr.
	-30.72	49.38			39	39	39			.1	.3

CROSS SECTION

RIVER: BUNKER CREEK
REACH: Route 4 RS: 322

INPUT

Description:

Station	Elevation	Data	num=	73							
Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev		
-198.62	20.64	-190.9	20	-176.53	19	-135.57	19	-133.39	20		
-131.2	20	-130.78	19	-97.01	18	-93.02	17	-89.04	16		
-85.06	15	-81.08	14	-77.09	13	-73.11	12	-69.13	11		
-65.15	10	-62.31	9	-60.34	8	-59.22	7	-58.1	6		
-57.13	5	-56.1	4	-55.06	3	-54.02	2	-52.99	1		
-51.95	0	-45.2	-1	-35.61	-2	-32.75	-3	-28.06	-3		
-23.08	-4	-16.74	-5	0	-6	15.24	-5	24.8	-4		
39.35	-3	74.05	-2	77.99	-1	81.92	0	86.3	0		
88.37	-1	97.72	-2	109.71	-2	151.65	-2	152.95	-1		
154.25	0	155.21	1	170.51	.6	384.88	.52	396.17	0		
422.32	-1	463.94	-1.81	467.98	-1	471.89	-.19	492.54	0		
545.31	1	553.04	2	586.25	3	593.07	4	598.61	5		
606.4	6	619.69	8	630.02	9	645.51	10	661.25	11		
674.11	12	695.68	13	736.96	14	744.06	14	754.22	14		
759.01	15	767.85	16	771.23	16.18						

Manning's n values	Sta	n Val	Sta	num=	5						
-198.62	.08	-54.02		n Val	.06	-32.75	n Val	.035	39.35	n Val	.06
Bank Sta:	Left	Right		Lengths:	Left	Channel	Right		Coeff	Contr.	Expan.
	-32.75	39.35			36	36	36		.1	.3	

CROSS SECTION

RIVER: BUNKER CREEK
REACH: Route 4 RS: 286

INPUT

Description:

Station	Elevation	Data	num=	85							
Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev		
-225.25	20.3	-220.14	20	-204.8	19	-176.22	18	-135.79	18		
-133.77	19	-130.75	19	-129.28	18	-113.11	19	-103.74	18		
-100.25	17	-96.78	16	-93.61	15	-89.83	14	-86.33	13		
-82.06	12	-77.78	11	-71.33	10	-70.53	9	-69.68	8		
-68.58	7	-67.48	6	-66.39	5	-65.29	4	-64.2	3		
-62.1	2	-57.93	1	-52.34	0	-47.72	-1	-37.97	-2		
-20.07	-3	-16.28	-4	-12.8	-5	-9.33	-6	-5.85	-7		
-2.55	-8	0	-8.56	11.23	-8	24.75	-7.77	26.62	-7		
29.74	-6	33.34	-5	37.41	-4	41.25	-3	74.89	-2		
75.57	-1	76.25	0	77.31	1	98.38	1.41	117.03	1		
119.36	0	121.67	-1	123.18	-1.7	297.63	-1.46	336.74	-2		
343.77	-1	349.94	0	352.9	.55	370.87	.69	373.96	0		
378.22	-1	380.3	-1.49	396.04	-1.19	429.02	-1.8	432.7	-1		

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437.06	0	457.34	1	495.4	1	517.61	2	543.71	3
563.16	4	568.42	5	572.88	6	578.27	7	583.66	8
589.05	9	594.44	10	599.75	11	610.23	12	635.19	13
653.01	13.5	656.38	13	662.97	12.56	669.38	13.44	681.65	14.67

Manning's n values	num=	5							
Sta n Val	Sta n Val	Sta n Val	Sta n Val	Sta n Val	Sta n Val	Sta n Val	Sta n Val	Sta n Val	
-225.25 .08	-62.1	.06	-20.07	.035	41.25	.06	543.71	.08	
Bank Sta: Left -20.07	Right 41.25	Lengths: Left 22	Channel 22	Right 22	Coeff .1	Contr. .1	Expan. .3		

CROSS SECTION

RIVER: BUNKER CREEK

REACH: Route 4

RS: 264

INPUT

Description: Approach Section

Station Elevation Data num=	75								
Sta Elev Sta Elev Sta Elev Sta Elev Sta Elev Sta Elev									
-247.69 20.57 -240.94 20 -227.82 19 -210.82 18 -184.98 17									
-154.26 16.82 -151.89 18.68 -149.82 18.63 -148.38 17.17 -125.58 17.9									
-118.96 17 -113.5 16 -108.03 15 -103.2 14 -98.9 13									
-94.6 12 -92.05 11 -91.17 10 -90.41 9 -90.29 8									
-88.53 7 -87.64 6 -86.58 5 -85.38 4 -84.19 3									
-82.99 2 -79.95 1 -71.53 0 -62.64 -1 -51.98 -2									
-42.67 -2 -36.7 -3 -32.74 -4 -30.84 -5 -28.34 -6									
-17.48 -7 -14.48 -7.71 -11.52 -7 -10.02 -8 0 -8.4									
.83 -8 4.67 -7 8.51 -6 12.36 -5 14.16 -4									
17.91 -3 36.7 -2.524 57.38 -2 58.51 -1 59.67 0									
60.71 .89 87.7 1.76 96.7 1 125.11 1.58 250.27 1									
313.94 0 352.31 -1 394.94 -1.44 398.14 -1 406.02 0									
415.87 1 429.75 2 463.51 3 471.7 4 478.95 5									
489.64 6 502.31 7 516.17 8 531.57 9 545.9 10									
558.87 11 563.84 11.38 577.04 11 592.31 12 615.31 13.37									

Manning's n values	num=	5							
Sta n Val	Sta n Val	Sta n Val	Sta n Val	Sta n Val	Sta n Val	Sta n Val	Sta n Val	Sta n Val	
-247.69 .08	-79.95	.06	-36.7	.035	17.91	.06	463.51	.08	

Bank Sta: Left -36.7	Right 36.7	Lengths: Left 19	Channel 19	Right 19	Coeff .3	Contr. .3	Expan. .5
----------------------	------------	------------------	------------	----------	----------	-----------	-----------

Ineffective Flow num=	2							
Sta L Sta R Elev Permanent								
-247.69 -64 1.76 F								
46 615.31 1.76 F								

CROSS SECTION

RIVER: BUNKER CREEK

REACH: Route 4

RS: 245

INPUT

Description: Upstream bridge section

Station Elevation Data num=	62								
Sta Elev Sta Elev Sta Elev Sta Elev Sta Elev Sta Elev									
-230.63 20.86 -221.87 20 -211.65 19 -201.51 18 -184.28 17									
-161.58 16 -140.49 17 -138.58 17 -136.63 15.69 -135.86 16									
-124.1 16.31 -115.91 16 -104.82 15 -97.62 14 -91.53 13									
-84.34 12 -81.83 11 -80.79 10 -79.81 9 -78.63 8									

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-77.54	7	-76.46	6	-75.38	5	-74.31	4	-73.23	3
-72.51	2.5	-59.46	2.8	-49.55	2	-39.58	1	-36.5	.735
-27.97	0	-25.99	-1	-19.97	-2	-8.8	-3	-.81	-4
0	-5.5	13.37	-4	18.24	-3	31.73	-2	36.5	-1.95
96.06	-1.32	124.46	-1	134.62	0	139.87	.45	230.5	1
279.53	.77	320.01	-.25	333.2	0	367.64	.65	401.78	1
426.35	2	466.79	3	472.28	4	481.11	5	488.3	6
502.11	7	513.18	8	526.58	9	552.89	10	567.2	11
582.05	12	595.81	12.7						

Manning's n	values	num=	5	Sta	n	val	Sta	n	val	Sta	n	val	Sta	n	val
-230.63	.08	-77.54	.06	-36.5	.035	36.5	.06	466.79	.08						
Bank Sta:	Left	Right	Lengths:	Left	channel	Right	Coeff	Contr.	Expan.						
	-36.5	36.5		61	61	61	.3		.5						
Ineffective Flow	num=	2													
Sta L	Sta R	Elev	Permanent												
-230.63	-42	11	F												
42	595.81	14	F												

BRIDGE

RIVER: BUNKER CREEK

REACH: Route 4

RS: 210

INPUT

Description:

Distance from Upstream XS = 8
 Deck/Roadway width = 38
 Weir Coefficient = 2.6
 Upstream Deck/Roadway Coordinates

num=	235	Sta	Hi	Cord	Lo	Cord	Sta	Hi	Cord	Lo	Cord	Sta	Hi	Cord	Lo	Cord
-400	10.23		-395		10.17		-390		10.11							
-385	10.06		-380		10		-375		9.95							
-370	9.9		-365		9.86		-360		9.81							
-355	9.77		-350		9.73		-345		9.69							
-340	9.65		-335		9.62		-330		9.58							
-325	9.55		-320		9.52		-315		9.49							
-310	9.47		-305		9.44		-300		9.41							
-295	9.38		-290		9.35		-285		9.33							
-280	9.31		-275		9.29		-270		9.28							
-265	9.27		-260		9.26		-255		9.25							
-250	9.25		-245		9.25		-240		9.26							
-235	9.26		-230		9.27		-225		9.29							
-220	9.3		-215		9.32		-210		9.34							
-205	9.37		-200		9.4		-195		9.43							
-190	9.47		-185		9.5		-180		9.54							
-175	9.59		-170		9.64		-165		9.69							
-160	9.74		-155		9.8		-150		9.86							
-145	9.92		-140		9.98		-135		10.05							
-130	10.12		-125		10.2		-120		10.28							
-115	10.36		-110		10.44		-105		10.53							
-100	10.62		-95		10.71		-90		10.81							
-85	10.91		-80		11.01		-75		11.12							
-70	11.23		-65		11.34		-60		11.46							
-55	11.57		-50		11.69		-45		11.82							
-40	11.95		-36.5		12	0	-36.5		12	8						
-35	12.08	8.08	-30	12.21	8.21	-25	12.35	8.35								
-20	12.49	8.49	-18.25	12.53	8.53	-15	12.63	8.63								
-10	12.78	8.78	-5	12.92	8.92	0	13.08	9.08								

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5	13.23	9.23	10	13.39	9.39	15	13.55
18.25	13.68	9.68	20	13.72	9.72	25	13.88
30	14.05	10.05	35	14.23	10.23	36.5	14.3
36.5	14.3	0	40	14.4		45	14.58
50	14.77		55	14.95		60	15.14
65	15.33		70	15.53		75	15.73
80	15.93		85	16.13		90	16.34
95	16.55		100	16.77		105	16.98
110	17.2		115	17.43		120	17.65
125	17.88		130	18.11		135	18.35
140	18.59		145	18.83		150	19.07
155	19.32		160	19.57		165	19.83
170	20.08		175	20.34		180	20.61
185	20.87		190	21.14		195	21.41
200	21.69		205	21.97		210	22.25
215	22.53		220	22.82		225	23.11
230	23.41		235	23.7		240	24
245	24.31		250	24.61		255	24.91
260	25.21		265	25.51		270	25.8
275	26.09		280	26.37		285	26.66
290	26.94		295	27.22		300	27.5
305	27.77		310	28.04		315	28.31
320	28.58		325	28.84		330	29.1
335	29.36		340	29.61		345	29.86
350	30.11		355	30.36		360	30.6
365	30.84		370	31.08		375	31.32
380	31.55		385	31.78		390	32.01
395	32.23		400	32.46		405	32.68
410	32.89		415	33.11		420	33.32
425	33.53		430	33.73		435	33.94
440	34.14		445	34.34		450	34.53
455	34.72		460	34.91		465	35.1
470	35.29		475	35.47		480	35.65
485	35.82		490	36		495	36.17
500	36.34		505	36.5		510	36.67
515	36.83		520	36.98		525	37.14
530	37.29		535	37.44		540	37.59
545	37.73		550	37.87		555	38.01
560	38.15		565	38.28		570	38.41
575	38.54		580	38.66		585	38.78
590	38.9		595	39.02		600	39.14
690	40.73		695	40.79		700	40.85
705	40.91		710	40.97		715	41.02
720	41.07		725	41.11		730	41.16
735	41.2		740	41.24		745	41.27
750	41.31		755	41.34		760	41.37
765	41.39		770	41.41		775	41.44
780	41.46		785	41.49		790	41.51
795	41.53		800	41.56		805	41.58
810	41.6		815	41.63		820	41.65
825	41.67						

Upstream Bridge Cross Section Data

Station	Elevation	Data num=	58	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
-230.63	20.86	-221.87		20	-211.65	19	-201.51	18	-184.28		17
-161.58	16	-140.49		17	-138.58	17	-136.63	15.69	-135.86		16
-124.1	16.31	-115.91		16	-104.82	15	-97.62	14	-91.53		13
-84.34	12	-81.83		11	-80.79	10	-79.81	9	-78.63		8
-77.54	7	-76.46		6	-75.38	5	-74.31	4	-73.23		3
-72.51	2.5	-59.46		2.8	-49.55	2	-39.58	1	-36.5		7
-34.5	7	-18.25		-3	0	-5.5	18.25	-3	34.5		9
36.5	9	96.06		-1.32	124.46	-1	134.62	0	139.87		.45

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230.5	1	279.53	.77	320.01	-.25	333.2	0	367.64	.65	
401.78	1	426.35	2	466.79	3	472.28	4	481.11	5	
488.3	6	502.11	7	513.18	8	526.58	9	552.89	10	
567.2	11	582.05	12	595.81	12.7					

Manning's n values num= 2
 Sta n Val Sta n Val
 -230.63 .06 96.06 .06

Bank Sta: Left Right Coeff Contr. Expan.
 -36.5 36.5 .3 .5

Ineffective Flow num= 2
 Sta L Sta R Elev Permanent
 -230.63 -42 11 F
 42 595.81 14 F

Downstream Deck/Roadway Coordinates

num= 235				Sta Hi Cord Lo Cord				Sta Hi Cord Lo Cord				Sta Hi Cord Lo Cord			
-400	10.23			-395	10.17			-390	10.11						
-385	10.06			-380	10			-375	9.95						
-370	9.9			-365	9.86			-360	9.81						
-355	9.77			-350	9.73			-345	9.69						
-340	9.65			-335	9.62			-330	9.58						
-325	9.55			-320	9.52			-315	9.49						
-310	9.47			-305	9.44			-300	9.41						
-295	9.38			-290	9.35			-285	9.33						
-280	9.31			-275	9.29			-270	9.28						
-265	9.27			-260	9.26			-255	9.25						
-250	9.25			-245	9.25			-240	9.26						
-235	9.26			-230	9.27			-225	9.29						
-220	9.3			-215	9.32			-210	9.34						
-205	9.37			-200	9.4			-195	9.43						
-190	9.47			-185	9.5			-180	9.54						
-175	9.59			-170	9.64			-165	9.69						
-160	9.74			-155	9.8			-150	9.86						
-145	9.92			-140	9.98			-135	10.05						
-130	10.12			-125	10.2			-120	10.28						
-115	10.36			-110	10.44			-105	10.53						
-100	10.62			-95	10.71			-90	10.81						
-85	10.91			-80	11.01			-75	11.12						
-70	11.23			-65	11.34			-60	11.46						
-55	11.57			-50	11.69			-45	11.82						
-40	11.95			-36.5	12	0	-36.5	12	8						
-35	12.08	8.08		-30	12.21	8.21	-25	12.35	8.35						
-20	12.49	8.49		-18.25	12.53	8.53	-15	12.63	8.63						
-10	12.78	8.78		-5	12.92	8.92	0	13.08	9.08						
5	13.23	9.23		10	13.39	9.39	15	13.55	9.55						
18.25	13.68	9.68		20	13.72	9.72	25	13.88	9.88						
30	14.05	10.05		35	14.23	10.23	36.5	14.3	10.3						
36.5	14.3	0		40	14.4		45	14.58							
50	14.77			55	14.95		60	15.14							
65	15.33			70	15.53		75	15.73							
80	15.93			85	16.13		90	16.34							
95	16.55			100	16.77		105	16.98							
110	17.2			115	17.43		120	17.65							
125	17.88			130	18.11		135	18.35							
140	18.59			145	18.83		150	19.07							
155	19.32			160	19.57		165	19.83							
170	20.08			175	20.34		180	20.61							
185	20.87			190	21.14		195	21.41							
200	21.69			205	21.97		210	22.25							
215	22.53			220	22.82		225	23.11							

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230	23.41	235	23.7	240	24
245	24.31	250	24.61	255	24.91
260	25.21	265	25.51	270	25.8
275	26.09	280	26.37	285	26.66
290	26.94	295	27.22	300	27.5
305	27.77	310	28.04	315	28.31
320	28.58	325	28.84	330	29.1
335	29.36	340	29.61	345	29.86
350	30.11	355	30.36	360	30.6
365	30.84	370	31.08	375	31.32
380	31.55	385	31.78	390	32.01
395	32.23	400	32.46	405	32.68
410	32.89	415	33.11	420	33.32
425	33.53	430	33.73	435	33.94
440	34.14	445	34.34	450	34.53
455	34.72	460	34.91	465	35.1
470	35.29	475	35.47	480	35.65
485	35.82	490	36	495	36.17
500	36.34	505	36.5	510	36.67
515	36.83	520	36.98	525	37.14
530	37.29	535	37.44	540	37.59
545	37.73	550	37.87	555	38.01
560	38.15	565	38.28	570	38.41
575	38.54	580	38.66	585	38.78
590	38.9	595	39.02	600	39.14
690	40.73	695	40.79	700	40.85
705	40.91	710	40.97	715	41.02
720	41.07	725	41.11	730	41.16
735	41.2	740	41.24	745	41.27
750	41.31	755	41.34	760	41.37
765	41.39	770	41.41	775	41.44
780	41.46	785	41.49	790	41.51
795	41.53	800	41.56	805	41.58
810	41.6	815	41.63	820	41.65
825	41.67				

Downstream Bridge Cross Section Data

Station	Elevation	Data	num=	60					
Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
-265.73	22.03	-251.99	21	-238.61	20	-223.71	19	-206.41	18
-185.62	17	-157.43	16	-133.97	15	-121.66	14	-112.12	13
-108.76	12	-107.74	11	-106.73	10	-105.57	9	-104.05	8
-99.81	8	-93.53	7.74	-89.33	8	-84.1	7	-77.77	6
-70.36	5	-57.7	4	-42.88	3	-36.5	7	-34.7	7
-18.5	-3	0	-5.5	18.5	-3	34.5	9	36.5	9
59.06	1	136.8	2	148.09	2.47	192.08	3	198.13	4
201.23	4.51	213.18	5	230.94	6	239.99	6	249.86	5
258.64	4	266.74	3.46	274.84	4	289.73	5	292.79	5.21
300.14	5	320.58	6	341.22	6.87	349.86	6.9	351.47	7
356.46	7.61	358.71	4.82	360.31	7	365.58	7	372.24	8
378.91	9	381.34	10	383.13	11	385.39	12	387.35	12.87

Manning's n Values num= 1

Sta	n	Val
-265.73	.06	

Bank Sta:	Left	Right	Coeff	Contr.	Expan.
	-36.5	36.5	.3	.5	

Ineffective Flow	Sta L	Sta R	Elev	Permanent
	-265.73	-42	10	F
	42	387.35	12	F

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Upstream Embankment side slope	=	0 horiz. to 1.0 vertical
Downstream Embankment side slope	=	0 horiz. to 1.0 vertical
Maximum allowable submergence for weir flow	=	.98
Elevation at which weir flow begins	=	
Energy head used in spillway design	=	
Spillway height used in design	=	
Weir crest shape	=	Broad Crested

Number of Bridge Coefficient Sets = 1

Low Flow Methods and Data
Energy

Selected Low Flow Methods = Highest Energy Answer

High Flow Method
Energy Only

Additional Bridge Parameters

Add Friction component to Momentum

Do not add weight component to Momentum

Class B flow critical depth computations use critical depth
inside the bridge at the upstream end

Criteria to check for pressure flow = Upstream energy grade line

CROSS SECTION

RIVER: BUNKER CREEK

REACH: Route 4

RS: 184

INPUT

Description: Downstream bridge section

Station	Elevation	Data num=	83	Station	Elevation	Station	Elevation	Station	Elevation	Station	Elevation
-265.73	22.03	-251.99		21	-238.61	20	-223.71	19	-206.41	18	
-185.62	17	-157.43		16	-133.97	15	-121.66	14	-112.12	13	
-108.76	12	-107.74		11	-106.73	10	-105.57	9	-104.05	8	
-99.81	8	-93.53		7.74	-89.33	8	-84.1	7	-77.77	6	
-70.36	5	-57.7		4	-42.88	3	-36.5	2.695	-28.47	2.31	
-27.81	2	-25.65		1	-23.5	0	-20.31	-1	-17.03	-2	
-13.79	-3	-10.96		-3.79	-9.81	-3.03	-8.14	-4	-6.73	-5	
-1.71	-6	0		-7	2.61	-6	3.97	-5	5.34	-4.19	
7.05	-5	8.93		-6	9.75	-6.45	10.39	-6	11.57	-5	
12.74	-4	14.36		-3	17.8	-3.79	21.1	-3	23.58	-2	
26.3	-1	32.89		0	36.5	.138	59.06	1	136.8	2	
148.09	2.47	192.08		3	198.13	4	201.23	4.51	213.18	5	
230.94	6	239.99		6	249.86	5	258.64	4	266.74	3.46	
274.84	4	289.73		5	292.79	5.21	300.14	5	320.58	6	
341.22	6.87	349.86		6.9	351.47	7	356.46	7.61	358.71	4.82	
360.31	7	365.58		7	372.24	8	378.91	9	381.34	10	
383.13	11	385.39		12	387.35	12.87					

Manning's n Values

Sta	n Val	Sta	n Val	Sta	n Val	Sta	n Val	Sta	n Val
-265.73	.08	-84.1	.06	-36.5	.03	36.5	.03	289.73	.06
341.22	.08								

Bank Sta:	Left	Right	Lengths:	Left	Channel	Right	Coeff	Contr.	Expan.
	-36.5	36.5		22	22	22		.3	.5

Ineffective Flow num= 2

Sta L	Sta R	Elev	Permanent
-265.73	-42	10	F
42	387.35	12	F

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CROSS SECTION

RIVER: BUNKER CREEK
REACH: Route 4

RS: 162

INPUT

Description:

Station	Elevation	Data	num=	71	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
-242.55	20	-230.62			19	-223.45		18	-219.16	17	-191.76	16
-160.52	15	-143.79			14	-130.98		13	-121.77	12	-119.71	11
-118.47	10	-117.22			9	-115.76		8	-112.95	9	-110.15	10
-108.73	10.5	-106.51			10	-104.46		9	-102.41	8	-100.36	7
-98.31	6	-95.69			5	-92.78		4	-88.95	3	-82.95	2
-74.66	1	-69.93			0	-60.83		-1	-52.57	-2	-51.76	-2.56
-45.75	-3	-41.57			-2.29	-39.21		-3	-36.9	-4	-33.01	-5
-28.5	-7	-24.66			-8	-19.1		-9	-13.66	-10	-12.26	-10.86
-6.45	-10	-.89			-11	0	-11.06		2.81	-10	4.47	-9.75
5.51	-10	7.45			-10.66	12.24		-10	14.12	-9	16.2	-8
18.28	-7	19.22			-6	19.71		-5	20.53	-4	22.67	-3.19
25.33	-3.64	30.12			-3	68.3		-2	167.06	-1.38	281.67	-1
320.61	0	325.89			1	330.21		2	338.34	3	347.84	4
351.83	5	356.38			6	363.23		7	364.78	8	365.72	9
369.97	9.9											

Manning's n Values

Sta	n Val	Sta	num=	5	Sta	n Val	Sta	n Val	Sta	n Val	Sta	n Val
-242.55	.08	-88.95			.06	-52.57		.03	22.67	.03	338.34	.08

Bank Sta:	Left	Right	Lengths:	Left	Channel	Right	Coeff	Contr.	Expan.
				31	31	31		.1	.3
	-45.75	22.67							

CROSS SECTION

RIVER: BUNKER CREEK
REACH: Route 4

RS: 131

INPUT

Description:

Station	Elevation	Data	num=	62	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
-229.74	20.84	-226.14			20	-221.84		19	-217.54	18	-213.24	17
-208.95	16	-188.81			15	-142.2		14	-124.64	13	-111.73	12
-99.48	11	-90.14			10	-85.36		9	-75.22	8	-72.59	7
-69.95	6	-67.31			5	-65.91		4	-64.82	3	-63.73	2
-62.63	1	-61.51			0	-60.99		-1	-55.37	-2	-45.91	-3
-42.07	-4	-39.39			-5	-34.4		-6	-29.74	-7	-26.9	-8
-23.42	-9	-19.46			-10	-13.09		-11	-4.74	-12	0	-12.43
1.5	-12	16.05			-11	16.61		-11	18.87	-10	21.14	-9
23.4	-8	25.67			-7	27.93		-6	30.2	-5	33.17	-4
34.8	-3	41.78			-2.11	53.53		-2	301.13	-1	307.67	-.82
308.37	0	309.19			1.27	317.71		2	331.62	3	345.09	4
346.88	5	347.88			5.75	348.92		6	351.47	6.49	352.14	7.61
353.86	8	354.95			8.25							

Manning's n Values

Sta	n Val	Sta	num=	5	Sta	n Val	Sta	n Val	Sta	n Val	Sta	n Val
-229.74	.08	-65.91			.06	-55.37		.03	41.78	.03	331.62	.08

Bank Sta:	Left	Right	Lengths:	Left	Channel	Right	Coeff	Contr.	Expan.

-55.37 41.78

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31 31 31

.1 .3

CROSS SECTION

RIVER: BUNKER CREEK

REACH: Route 4

RS: 100

INPUT

Description:

Station	Elevation	Data	num=	59	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
-244.17	21.12	-236.17			20	-229.05		19	-221.92	18	-215.46	17
-211.21	16	-206.96			15	-191.29		14	-167.44	13	-146.68	13.58
-120.7	13	-108.98			12	-107.74		11	-106.5	10	-105.26	9
-104.02	8	-102.37			7	-100.24		6	-98.12	5	-95.74	4
-90.14	3	-83.45			2	-72.11		1	-67.02	0	-62.97	-1
-59.3	-2	-49.32			-3	-46		-4	-43.58	-5	-39.68	-6
-36.52	-7	-33.77			-8	-30.08		-9	-16.01	-9.85	-3.03	-9.34
0	-9.86	12.4			-9	16.36		-8	20.12	-7	23.81	-6
26.51	-5	29.2			-4	32.6		-3	46.82	-2	280.85	-1.09
281.73	.83	282.92			1	291.76		2	300.94	3	311.99	4
313.38	4.13	314.3			5	315.33		6	316.38	7	316.96	7.57
321.65	8	327.96			8.58	329.65		9	330.83	9.28		

Manning's n Values

Sta	n	Val	Sta	num=	5	Sta	n	Val	Sta	n	Val	
-244.17	.08	-83.45			.06	-59.3		.03	46.82	.03	291.76	.08

Bank Sta:	Left	Right	Lengths:	Left	Channel	Right	Coeff	Contr.	Expan.
	-59.3	46.82		38		38		.1	.3

CROSS SECTION

RIVER: BUNKER CREEK

REACH: Route 4

RS: 62

INPUT

Description: Confluence with Oyster River

Station	Elevation	Data	num=	51	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
-244.17	21.12	-236.17			20	-229.05		19	-221.92	18	-215.46	17
-211.21	16	-206.96			15	-191.29		14	-167.44	13	-146.68	13.58
-120.7	13	-108.98			12	-107.74		11	-106.5	10	-105.26	9
-104.02	8	-102.37			7	-100.24		6	-98.12	5	-95.74	4
-90.14	3	-83.45			2	-72.11		1	-67.02	0	-62.97	-1
-59.3	-2	-49.32			-3	-35		-4	-16.01	-4.3	-3.03	-4.4
0	-4.5	12.4			-4.4	16.36		-4.3	29.2	-4	32.6	-3
46.82	-2	280.85			-1.09	281.73		.83	282.92	1	291.76	2
300.94	3	311.99			4	313.38		4.13	314.3	5	315.33	6
316.38	7	316.96			7.57	321.65		8	327.96	8.58	329.65	9
330.83	9.28											

Manning's n Values

Sta	n	Val	Sta	num=	5	Sta	n	Val	Sta	n	Val	
-244.17	.08	-83.45			.06	-59.3		.03	46.82	.03	291.76	.08

Bank Sta:	Left	Right	Lengths:	Left	Channel	Right	Coeff	Contr.	Expan.
	-59.3	46.82		0	0	0		.1	.3

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SUMMARY OF MANNING'S N VALUES

River: BUNKER CREEK

n6	Reach	River Sta.	n1	n2	n3	n4	n5
Route 4		361	.08	.06	.035	.06	.08
Route 4		322	.08	.06	.035	.06	.08
Route 4		286	.08	.06	.035	.06	.08
Route 4		264	.08	.06	.035	.06	.08
Route 4		245	.08	.06	.035	.06	.08
Route 4		210	Bridge				
Route 4		184	.08	.06	.03	.03	.06
.08	Route 4	162	.08	.06	.03	.03	.08
Route 4		131	.08	.06	.03	.03	.08
Route 4		100	.08	.06	.03	.03	.08
Route 4		62	.08	.06	.03	.03	.08

SUMMARY OF REACH LENGTHS

River: BUNKER CREEK

Reach	River Sta.	Left	channel	Right
Route 4	361	39	39	39
Route 4	322	36	36	36
Route 4	286	22	22	22
Route 4	264	19	19	19
Route 4	245	61	61	61
Route 4	210	Bridge		
Route 4	184	22	22	22
Route 4	162	31	31	31
Route 4	131	31	31	31
Route 4	100	38	38	38
Route 4	62	0	0	0

SUMMARY OF CONTRACTION AND EXPANSION COEFFICIENTS
River: BUNKER CREEK

Reach	River Sta.	Contr.	Expan.
-------	------------	--------	--------

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Route 4	361	.1	.3
Route 4	322	.1	.3
Route 4	286	.1	.3
Route 4	264	.3	.5
Route 4	245	.3	.5
Route 4	210	Bridge	
Route 4	184	.3	.5
Route 4	162	.1	.3
Route 4	131	.1	.3
Route 4	100	.1	.3
Route 4	62	.1	.3

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HEC-RAS HEC-RAS 5.0.3 September 2016
U.S. Army Corps of Engineers
Hydrologic Engineering Center
609 Second Street
Davis, California

X	X	XXXXXX	XXXX	XXXX	XX	XXXX
X	X	X	X X	X X	X X	X
X	X	X	X	X X	X X	X
XXXXXXX	XXXX	X	XXX	XXXX	XXXXXX	XXXX
X	X	X	X	X X	X X	X
X	X	X	X X	X X	X X	X
X	X	XXXXXX	XXXX	X X	X X	XXXXX

PROJECT DATA

Project Title: SBdg#16236-Rte 4 ov Bunker Ck Durham NH

Project File : 16236_PerlimDes_20ct17.prj

Run Date and Time: 11/22/2017 11:44:04 AM

Project in English units

PLAN DATA

Plan Title: Proposed Cond. Slack Tide

Plan File : t:\Projects\New Hampshire\Durham_16236\16236 - Part A\Computations\Hydraulics\1D HEC-RAS model\16236_PerlimDes_20ct17.p03

Geometry Title: Bunker Creek Proposed Condition

Geometry File : t:\Projects\New Hampshire\Durham_16236\16236 - Part A\Computations\Hydraulics\1D HEC-RAS model\16236_PerlimDes_20ct17.g02

Flow Title : Riverine with slack Tide

Flow File : t:\Projects\New Hampshire\Durham_16236\16236 - Part A\Computations\Hydraulics\1D HEC-RAS model\16236_PerlimDes_20ct17.f02

Plan Summary Information:

Number of: Cross Sections = 10 Multiple Openings = 0
 Culverts = 0 Inline Structures = 0
 Bridges = 1 Lateral Structures = 0

Computational Information

Water surface calculation tolerance = 0.01

Critical depth calculation tolerance = 0.01

Maximum number of iterations = 20

Maximum difference tolerance = 0.3

Flow tolerance factor = 0.001

Computation Options

Critical depth computed only where necessary

Conveyance Calculation Method: At breaks in n values only

Friction Slope Method: Average Conveyance

Computational Flow Regime: Subcritical Flow

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FLOW DATA

Flow Title: Riverine with Slack Tide

Flow File : t:\Projects\New Hampshire\Durham_16236\16236 - Part A\Computations\Hydraulics\1D HEC-RAS model\16236_PerlimDes_20ct17.f02

Flow Data (cfs)

River Q 500	Reach	RS	Q 100	Q 200
BUNKER CREEK 300	Route 4	361	200	250

Boundary Conditions

River Downstream	Reach	Profile	Upstream
BUNKER CREEK Normal S = 0.001	Route 4	Q 100	

GEOMETRY DATA

Geometry Title: Bunker Creek Proposed Condition

Geometry File : t:\Projects\New Hampshire\Durham_16236\16236 - Part A\Computations\Hydraulics\1D HEC-RAS model\16236_PerlimDes_20ct17.g02

CROSS SECTION

RIVER: BUNKER CREEK

REACH: Route 4 RS: 361

INPUT

Description: Last upstream river section

Station	Elevation	Data num=	59	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
-195.13	20.23	-193.28		20	-181.41	19	-169.23	18	-157.05	17	
-137.11	16	-124.63		15	-102.74	14	-99.39	13	-96.68	12	
-93.16	11	-89.64		10	-86.13	9	-82.61	8	-79.09	7	
-75.58	6	-72.06		5	-68.54	4	-64.5	3	-60.36	2	
-56.21	1	-49.57		0	-42.11	-1	-30.72	-2	-20.99	-3	
-10.74	-3	0	-3.64	10	9.98	-3	49.38	-2	61.88	-1.22	
69.42	-2	93.72		-2	104.87	-1	106.21	-2	107.42	-3	
110.06	-2	112.44		-1	114.46	-.02	559.43	1.24	569.4	2	
586.94	3	593.39		4	598.84	5	613.51	6	622.86	7	
634.88	8	649.37		9	661.35	10	671.18	11	680.75	12	
703.65	13	751.63		14	793.18	14	808.85	15	813.1	15	
816.59	15	821.32		16	827.45	17	835.7	17.45			

Manning's n	Values num=	5	Sta	n Val	Sta	n Val	Sta	n Val	Sta	n Val
-195.13	.08	-60.36	.06	-30.72	.035	49.38	.06	569.4	.08	

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 Bank Sta: Left Right Lengths: Left channel Right Coeff Contr. Expan.
 -30.72 49.38 39 39 39 .1 .3

CROSS SECTION

RIVER: BUNKER CREEK
 REACH: Route 4 RS: 322

INPUT

Description:

Station	Elevation	Data	num=	73	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
-198.62	20.64	-190.9		20	-176.53	19	-135.57	19	-133.39	19	-133.39	20
-131.2	20	-130.78		19	-97.01	18	-93.02	17	-89.04	17	-89.04	16
-85.06	15	-81.08		14	-77.09	13	-73.11	12	-69.13	12	-69.13	11
-65.15	10	-62.31		9	-60.34	8	-59.22	7	-58.1	7	-58.1	6
-57.13	5	-56.1		4	-55.06	3	-54.02	2	-52.99	2	-52.99	1
-51.95	0	-45.2		-1	-35.61	-2	-32.75	-3	-28.06	-3	-28.06	-3
-23.08	-4	-16.74		-5	0	-6	15.24	-5	24.8	-5	24.8	-4
39.35	-3	74.05		-2	77.99	-1	81.92	0	86.3	0	86.3	0
88.37	-1	97.72		-2	109.71	-2	151.65	-2	152.95	-2	152.95	-1
154.25	0	155.21		1	170.51	.6	384.88	.52	396.17	.52	396.17	0
422.32	-1	463.94		-1.81	467.98	-1	471.89	-.19	492.54	-.19	492.54	0
545.31	1	553.04		2	586.25	3	593.07	4	598.61	4	598.61	5
606.4	6	619.69		8	630.02	9	645.51	10	661.25	10	661.25	11
674.11	12	695.68		13	736.96	14	744.06	14	754.22	14	754.22	14
759.01	15	767.85		16	771.23	16.18						

Manning's n	values	num=	5	Sta	n	val	Sta	n	val	Sta	n	val	
-198.62	.08		-54.02		.06		-32.75		.035		39.35		.06

Bank Sta: Left Right Lengths: Left channel Right Coeff Contr. Expan.
 -32.75 39.35 36 36 36 .1 .3

CROSS SECTION

RIVER: BUNKER CREEK
 REACH: Route 4 RS: 286

INPUT

Description:

Station	Elevation	Data	num=	85	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
-225.25	20.3	-220.14		20	-204.8	19	-176.22	18	-135.79	18	-135.79	18
-133.77	19	-130.75		19	-129.28	18	-113.11	19	-103.74	18	-103.74	18
-100.25	17	-96.78		16	-93.61	15	-89.83	14	-86.33	13	-86.33	13
-82.06	12	-77.78		11	-71.33	10	-70.53	9	-69.68	8	-69.68	8
-68.58	7	-67.48		6	-66.39	5	-65.29	4	-64.2	3	-64.2	3
-62.1	2	-57.93		1	-52.34	0	-47.72	-1	-37.97	-2	-37.97	-2
-20.07	-3	-16.28		-4	-12.8	-5	-9.33	-6	-5.85	-7	-5.85	-7
-2.55	-8	0		-8.56	11.23	-8	24.75	-7.77	26.62	-7	26.62	-7
29.74	-6	33.34		-5	37.41	-4	41.25	-3	74.89	-2	74.89	-2
75.57	-1	76.25		0	77.31	1	98.38	1.41	117.03	1	117.03	1
119.36	0	121.67		-1	123.18	-1.7	297.63	-1.46	336.74	-2	336.74	-2
343.77	-1	349.94		0	352.9	.55	370.87	.69	373.96	0	373.96	0
378.22	-1	380.3		-1.49	396.04	-1.19	429.02	-1.8	432.7	-1	432.7	-1
437.06	0	457.34		1	495.4	1	517.61	2	543.71	3	543.71	3
563.16	4	568.42		5	572.88	6	578.27	7	583.66	8	583.66	8
589.05	9	594.44		10	599.75	11	610.23	12	635.19	13	635.19	13
653.01	13.5	656.38		13	662.97	12.56	669.38	13.44	681.65	14.67	681.65	14.67

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Manning's n Values	Sta	n Val	Sta	n Val	5	Sta	n Val	Sta	n Val	Sta	n Val
-225.25	.08	-62.1	.06	-20.07		.035	41.25	.06	543.71	.08	
Bank Sta: Left Right			Lengths: Left Channel			Right	Coeff	Contr.	Expan.		
-20.07	41.25	22	22	22			.1		.3		

CROSS SECTION

RIVER: BUNKER CREEK

REACH: Route 4

RS: 264

INPUT

Description: Approach Section

Station	Elevation	Data	num=	75							
Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
-247.69	20.57	-240.94	20	-227.82	19	-210.82	18	-184.98	17		
-154.26	16.82	-151.89	18.68	-149.82	18.63	-148.38	17.17	-125.58	17.9		
-118.96	17	-113.5	16	-108.03	15	-103.2	14	-98.9	13		
-94.6	12	-92.05	11	-91.17	10	-90.41	9	-90.29	8		
-88.53	7	-87.64	6	-86.58	5	-85.38	4	-84.19	3		
-82.99	2	-79.95	1	-71.53	0	-62.64	-1	-51.98	-2		
-42.67	-2	-36.7	-3	-32.74	-4	-30.84	-5	-28.34	-6		
-17.48	-7	-14.48	-7.71	-11.52	-7	-10.02	-8	0	-8.4		
.83	-8	4.67	-7	8.51	-6	12.36	-5	14.16	-4		
17.91	-3	36.7	-2.524	57.38	-2	58.51	-1	59.67	0		
60.71	.89	87.7	1.76	96.7	1	125.11	1.58	250.27	1		
313.94	0	352.31	-1	394.94	-1.44	398.14	-1	406.02	0		
415.87	1	429.75	2	463.51	3	471.7	4	478.95	5		
489.64	6	502.31	7	516.17	8	531.57	9	545.9	10		
558.87	11	563.84	11.38	577.04	11	592.31	12	615.31	13.37		

Manning's n Values

Sta	n Val	Sta	n Val	Sta	n Val	Sta	n Val	Sta	n Val
-247.69	.08	-79.95	.06	-36.7	.035	17.91	.06	463.51	.08

Bank Sta: Left Right

Left	Right	Lengths:	Left	Channel	Right	Coeff	Contr.	Expan.
-36.7	36.7		19	19	19	.3		.5

Ineffective Flow

Sta L	Sta R	Elev	Permanent
-247.69	-64	1.76	F
46	615.31	1.76	F

CROSS SECTION

RIVER: BUNKER CREEK

REACH: Route 4

RS: 245

INPUT

Description: Upstream bridge section

Station	Elevation	Data	num=	62							
Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
-230.63	20.86	-221.87	20	-211.65	19	-201.51	18	-184.28	17		
-161.58	16	-140.49	17	-138.58	17	-136.63	15.69	-135.86	16		
-124.1	16.31	-115.91	16	-104.82	15	-97.62	14	-91.53	13		
-84.34	12	-81.83	11	-80.79	10	-79.81	9	-78.63	8		
-77.54	7	-76.46	6	-75.38	5	-74.31	4	-73.23	3		
-72.51	2.5	-59.46	2.8	-49.55	2	-39.58	1	-36.5	.735		
-27.97	0	-25.99	-1	-19.97	-2	-8.8	-3	-.81	-4		
0	-5.5	13.37	-4	18.24	-3	31.73	-2	36.5	-1.95		

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96.06	-1.32	124.46	-1	134.62	0	139.87	.45	230.5	1		
279.53	.77	320.01	-.25	333.2	0	367.64	.65	401.78	1		
426.35	2	466.79	3	472.28	4	481.11	5	488.3	6		
502.11	7	513.18	8	526.58	9	552.89	10	567.2	11		
582.05	12	595.81	12.7								

Manning's n Values											
Sta	n	Val	Sta	num=	5	Sta	n	Val	Sta	n	Val
-230.63	.08	-77.54		.06		-36.5	.035		36.5	.06	466.79
											.08
Bank Sta:			Left	Right	Lengths:	Left	Channel	Right	Coeff	Contr.	Expan.
			-36.5	36.5		61	61	61	.3		.5
Ineffective Flow num= 2											
Sta L	Sta R	Elev	Permanent								
-230.63	-42	11	F								
42	595.81	14	F								

BRIDGE

RIVER: BUNKER CREEK
 REACH: Route 4 RS: 210

INPUT

Description:

Distance from Upstream XS = 8
 Deck/Roadway Width = 38
 Weir Coefficient = 2.6

Upstream Deck/Roadway Coordinates

Sta	Hi	Cord	Lo	Cord	Sta	Hi	Cord	Lo	Cord	Sta	Hi	Cord	Lo	Cord
-400	10.23				-395	10.17				-390	10.11			
-385	10.06				-380		10			-375	9.95			
-370	9.9				-365		9.86			-360	9.81			
-355	9.77				-350		9.73			-345	9.69			
-340	9.65				-335		9.62			-330	9.58			
-325	9.55				-320		9.52			-315	9.49			
-310	9.47				-305		9.44			-300	9.41			
-295	9.38				-290		9.35			-285	9.33			
-280	9.31				-275		9.29			-270	9.28			
-265	9.27				-260		9.26			-255	9.25			
-250	9.25				-245		9.25			-240	9.26			
-235	9.26				-230		9.27			-225	9.29			
-220	9.3				-215		9.32			-210	9.34			
-205	9.37				-200		9.4			-195	9.43			
-190	9.47				-185		9.5			-180	9.54			
-175	9.59				-170		9.64			-165	9.69			
-160	9.74				-155		9.8			-150	9.86			
-145	9.92				-140		9.98			-135	10.05			
-130	10.12				-125		10.2			-120	10.28			
-115	10.36				-110		10.44			-105	10.53			
-100	10.62				-95		10.71			-90	10.81			
-85	10.91				-80		11.01			-75	11.12			
-70	11.23				-65		11.34			-60	11.46			
-55	11.57				-50		11.69			-45	11.82			
-40	11.95				-36.5		12	0		-36.5	12			8
-35	12.08	8.08			-30	12.21		8.21		-25	12.35			8.35
-20	12.49	8.49			-18.25	12.53		8.53		-15	12.63			8.63
-10	12.78	8.78			-5	12.92		8.92	0	13.08				9.08
5	13.23	9.23			10	13.39		9.39		15	13.55			9.55
18.25	13.68	9.68			20	13.72		9.72		25	13.88			9.88
30	14.05	10.05			35	14.23		10.23		36.5	14.3			10.3
36.5	14.3	0			40	14.4				45	14.58			

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50	14.77	55	14.95	60	15.14
65	15.33	70	15.53	75	15.73
80	15.93	85	16.13	90	16.34
95	16.55	100	16.77	105	16.98
110	17.2	115	17.43	120	17.65
125	17.88	130	18.11	135	18.35
140	18.59	145	18.83	150	19.07
155	19.32	160	19.57	165	19.83
170	20.08	175	20.34	180	20.61
185	20.87	190	21.14	195	21.41
200	21.69	205	21.97	210	22.25
215	22.53	220	22.82	225	23.11
230	23.41	235	23.7	240	24
245	24.31	250	24.61	255	24.91
260	25.21	265	25.51	270	25.8
275	26.09	280	26.37	285	26.66
290	26.94	295	27.22	300	27.5
305	27.77	310	28.04	315	28.31
320	28.58	325	28.84	330	29.1
335	29.36	340	29.61	345	29.86
350	30.11	355	30.36	360	30.6
365	30.84	370	31.08	375	31.32
380	31.55	385	31.78	390	32.01
395	32.23	400	32.46	405	32.68
410	32.89	415	33.11	420	33.32
425	33.53	430	33.73	435	33.94
440	34.14	445	34.34	450	34.53
455	34.72	460	34.91	465	35.1
470	35.29	475	35.47	480	35.65
485	35.82	490	36	495	36.17
500	36.34	505	36.5	510	36.67
515	36.83	520	36.98	525	37.14
530	37.29	535	37.44	540	37.59
545	37.73	550	37.87	555	38.01
560	38.15	565	38.28	570	38.41
575	38.54	580	38.66	585	38.78
590	38.9	595	39.02	600	39.14
690	40.73	695	40.79	700	40.85
705	40.91	710	40.97	715	41.02
720	41.07	725	41.11	730	41.16
735	41.2	740	41.24	745	41.27
750	41.31	755	41.34	760	41.37
765	41.39	770	41.41	775	41.44
780	41.46	785	41.49	790	41.51
795	41.53	800	41.56	805	41.58
810	41.6	815	41.63	820	41.65
825	41.67				

Upstream Bridge Cross Section Data

Station	Elevation	Data num=	58	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
-230.63	20.86	-221.87		20	-211.65	19	-201.51	18	-184.28	17	
-161.58	16	-140.49		17	-138.58	17	-136.63	15.69	-135.86	16	
-124.1	16.31	-115.91		16	-104.82	15	-97.62	14	-91.53	13	
-84.34	12	-81.83		11	-80.79	10	-79.81	9	-78.63	8	
-77.54	7	-76.46		6	-75.38	5	-74.31	4	-73.23	3	
-72.51	2.5	-59.46		2.8	-49.55	2	-39.58	1	-36.5	7	
-34.5	7	-18.25		-3	0	-5.5	18.25	-3	34.5	9	
36.5	9	96.06	-1.32	124.46	-1	134.62	0	139.87	.45		
230.5	1	279.53	.77	320.01	-.25	333.2	0	367.64	.65		
401.78	1	426.35	2	466.79	3	472.28	4	481.11	5		
488.3	6	502.11	7	513.18	8	526.58	9	552.89	10		
567.2	11	582.05	12	595.81	12.7						

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Manning's n Values num= 2
 Sta n Val Sta n Val
 -230.63 .06 96.06 .06

Bank Sta: Left Right Coeff Contr. Expan.
 -36.5 36.5 .3 .5

Ineffective Flow num= 2
 Sta L Sta R Elev Permanent
 -230.63 -42 11 F
 42 595.81 14 F

Downstream Deck/Roadway Coordinates

Sta	Hi	Cord	Lo	Cord	Sta	Hi	Cord	Lo	Cord	Sta	Hi	Cord	Lo	Cord
-400	10.23				-395	10.17				-390	10.11			
-385	10.06				-380	10				-375	9.95			
-370	9.9				-365	9.86				-360	9.81			
-355	9.77				-350	9.73				-345	9.69			
-340	9.65				-335	9.62				-330	9.58			
-325	9.55				-320	9.52				-315	9.49			
-310	9.47				-305	9.44				-300	9.41			
-295	9.38				-290	9.35				-285	9.33			
-280	9.31				-275	9.29				-270	9.28			
-265	9.27				-260	9.26				-255	9.25			
-250	9.25				-245	9.25				-240	9.26			
-235	9.26				-230	9.27				-225	9.29			
-220	9.3				-215	9.32				-210	9.34			
-205	9.37				-200	9.4				-195	9.43			
-190	9.47				-185	9.5				-180	9.54			
-175	9.59				-170	9.64				-165	9.69			
-160	9.74				-155	9.8				-150	9.86			
-145	9.92				-140	9.98				-135	10.05			
-130	10.12				-125	10.2				-120	10.28			
-115	10.36				-110	10.44				-105	10.53			
-100	10.62				-95	10.71				-90	10.81			
-85	10.91				-80	11.01				-75	11.12			
-70	11.23				-65	11.34				-60	11.46			
-55	11.57				-50	11.69				-45	11.82			
-40	11.95				-36.5	12	0			-36.5	12			8
-35	12.08	8.08			-30	12.21	8.21			-25	12.35			8.35
-20	12.49	8.49			-18.25	12.53	8.53			-15	12.63			8.63
-10	12.78	8.78			-5	12.92	8.92			0	13.08			9.08
5	13.23	9.23			10	13.39	9.39			15	13.55			9.55
18.25	13.68	9.68			20	13.72	9.72			25	13.88			9.88
30	14.05	10.05			35	14.23	10.23			36.5	14.3			10.3
36.5	14.3	0			40	14.4				45	14.58			
50	14.77				55	14.95				60	15.14			
65	15.33				70	15.53				75	15.73			
80	15.93				85	16.13				90	16.34			
95	16.55				100	16.77				105	16.98			
110	17.2				115	17.43				120	17.65			
125	17.88				130	18.11				135	18.35			
140	18.59				145	18.83				150	19.07			
155	19.32				160	19.57				165	19.83			
170	20.08				175	20.34				180	20.61			
185	20.87				190	21.14				195	21.41			
200	21.69				205	21.97				210	22.25			
215	22.53				220	22.82				225	23.11			
230	23.41				235	23.7				240	24			
245	24.31				250	24.61				255	24.91			
260	25.21				265	25.51				270	25.8			
275	26.09				280	26.37				285	26.66			

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290	26.94	295	27.22	300	27.5
305	27.77	310	28.04	315	28.31
320	28.58	325	28.84	330	29.1
335	29.36	340	29.61	345	29.86
350	30.11	355	30.36	360	30.6
365	30.84	370	31.08	375	31.32
380	31.55	385	31.78	390	32.01
395	32.23	400	32.46	405	32.68
410	32.89	415	33.11	420	33.32
425	33.53	430	33.73	435	33.94
440	34.14	445	34.34	450	34.53
455	34.72	460	34.91	465	35.1
470	35.29	475	35.47	480	35.65
485	35.82	490	36	495	36.17
500	36.34	505	36.5	510	36.67
515	36.83	520	36.98	525	37.14
530	37.29	535	37.44	540	37.59
545	37.73	550	37.87	555	38.01
560	38.15	565	38.28	570	38.41
575	38.54	580	38.66	585	38.78
590	38.9	595	39.02	600	39.14
690	40.73	695	40.79	700	40.85
705	40.91	710	40.97	715	41.02
720	41.07	725	41.11	730	41.16
735	41.2	740	41.24	745	41.27
750	41.31	755	41.34	760	41.37
765	41.39	770	41.41	775	41.44
780	41.46	785	41.49	790	41.51
795	41.53	800	41.56	805	41.58
810	41.6	815	41.63	820	41.65
825	41.67				

Downstream Bridge Cross Section Data
 Station Elevation Data num= 60

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
-265.73	22.03	-251.99	21	-238.61	20	-223.71	19	-206.41	18
-185.62	17	-157.43	16	-133.97	15	-121.66	14	-112.12	13
-108.76	12	-107.74	11	-106.73	10	-105.57	9	-104.05	8
-99.81	8	-93.53	7.74	-89.33	8	-84.1	7	-77.77	6
-70.36	5	-57.7	4	-42.88	3	-36.5	7	-34.7	7
-18.5	-3	0	-5.5	18.5	-3	34.5	9	36.5	9
59.06	1	136.8	2	148.09	2.47	192.08	3	198.13	4
201.23	4.51	213.18	5	230.94	6	239.99	6	249.86	5
258.64	4	266.74	3.46	274.84	4	289.73	5	292.79	5.21
300.14	5	320.58	6	341.22	6.87	349.86	6.9	351.47	7
356.46	7.61	358.71	4.82	360.31	7	365.58	7	372.24	8
378.91	9	381.34	10	383.13	11	385.39	12	387.35	12.87

Manning's n Values num= 1

Sta	n Val
-265.73	.06

Bank Sta: Left Right Coeff Contr. Expan.
 -36.5 36.5 .3 .5

Ineffective Flow num= 2

Sta L	Sta R	Elev	Permanent
-265.73	-42	10	F
42	387.35	12	F

Upstream Embankment side slope = 0 horiz. to 1.0 vertical
 Downstream Embankment side slope = 0 horiz. to 1.0 vertical
 Maximum allowable submergence for weir flow = .98
 Elevation at which weir flow begins =

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Energy head used in spillway design	=
Spillway height used in design	=
Weir crest shape	= Broad Crested

Number of Bridge Coefficient Sets = 1

Low Flow Methods and Data

 Energy

Selected Low Flow Methods = Highest Energy Answer

High Flow Method

 Energy Only

Additional Bridge Parameters

 Add Friction component to Momentum

 Do not add Weight component to Momentum

 Class B flow critical depth computations use critical depth
 inside the bridge at the upstream end

 Criteria to check for pressure flow = Upstream energy grade line

CROSS SECTION

RIVER: BUNKER CREEK

REACH: Route 4

RS: 184

INPUT

Description: Downstream bridge section

Station	Elevation	Data num=	83	Station	Elevation	Station	Elevation	Station	Elevation	Station	Elevation
-265.73	22.03	-251.99		21	-238.61	20	-223.71	19	-206.41	18	
-185.62	17	-157.43		16	-133.97	15	-121.66	14	-112.12	13	
-108.76	12	-107.74		11	-106.73	10	-105.57	9	-104.05	8	
-99.81	8	-93.53		7.74	-89.33	8	-84.1	7	-77.77	6	
-70.36	5	-57.7		4	-42.88	3	-36.5	2.695	-28.47	2.31	
-27.81	2	-25.65		1	-23.5	0	-20.31	-1	-17.03	-2	
-13.79	-3	-10.96		-3.79	-9.81	-3.03	-8.14	-4	-6.73	-5	
-1.71	-6	0		-7	2.61	-6	3.97	-5	5.34	-4.19	
7.05	-5	8.93		-6	9.75	-6.45	10.39	-6	11.57	-5	
12.74	-4	14.36		-3	17.8	-3.79	21.1	-3	23.58	-2	
26.3	-1	32.89		0	36.5	.138	59.06	1	136.8	2	
148.09	2.47	192.08		3	198.13	4	201.23	4.51	213.18	5	
230.94	6	239.99		6	249.86	5	258.64	4	266.74	3.46	
274.84	4	289.73		5	292.79	5.21	300.14	5	320.58	6	
341.22	6.87	349.86		6.9	351.47	7	356.46	7.61	358.71	4.82	
360.31	7	365.58		7	372.24	8	378.91	9	381.34	10	
383.13	11	385.39		12	387.35	12.87					

Manning's n values

Sta	n Val	Sta	n Val	Sta	n Val	Sta	n Val	Sta	n Val
-265.73	.08	-84.1	.06	-36.5	.03	36.5	.03	289.73	.06
341.22	.08								

Bank Sta:	Left	Right	Lengths:	Left	Channel	Right	Coeff	Contr.	Expan.
	-36.5	36.5		22	22	22	.3	.5	

Ineffective Flow num=	2		
Sta L	Sta R	Elev	Permanent
-265.73	-42	10	F
42	387.35	12	F

CROSS SECTION

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RIVER: BUNKER CREEK
REACH: Route 4

RS: 162

INPUT

Description:

Station Elevation Data			num= 71								
Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
-242.55	20	-230.62	19	-223.45	18	-219.16	17	-219.76	16		
-160.52	15	-143.79	14	-130.98	13	-121.77	12	-119.71	11		
-118.47	10	-117.22	9	-115.76	8	-112.95	9	-110.15	10		
-108.73	10.5	-106.51	10	-104.46	9	-102.41	8	-100.36	7		
-98.31	6	-95.69	5	-92.78	4	-88.95	3	-82.95	2		
-74.66	1	-69.93	0	-60.83	-1	-52.57	-2	-51.76	-2.56		
-45.75	-3	-41.57	-2.29	-39.21	-3	-36.9	-4	-33.01	-5		
-28.5	-7	-24.66	-8	-19.1	-9	-13.66	-10	-12.26	-10.86		
-6.45	-10	-.89	-11	0	-11.06	2.81	-10	4.47	-9.75		
5.51	-10	7.45	-10.66	12.24	-10	14.12	-9	16.2	-8		
18.28	-7	19.22	-6	19.71	-5	20.53	-4	22.67	-3.19		
25.33	-3.64	30.12	-3	68.3	-2	167.06	-1.38	281.67	-1		
320.61	0	325.89	1	330.21	2	338.34	3	347.84	4		
351.83	5	356.38	6	363.23	7	364.78	8	365.72	9		
369.97	9.9										

Manning's n Values

Sta n Val			num= 5								
Sta	n Val	Sta	n Val	Sta	n Val	Sta	n Val	Sta	n Val	Sta	n Val
-242.55	.08	-88.95	.06	-52.57	.03	22.67	.03	338.34	.08		

Bank Sta: Left Right		Lengths: Left Channel			Right		Coeff	Contr.	Expan.
		31	31	31			.1	.3	
-45.75	22.67								

CROSS SECTION

RIVER: BUNKER CREEK
REACH: Route 4

RS: 131

INPUT

Description:

Station Elevation Data			num= 62								
Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
-229.74	20.84	-226.14	20	-221.84	19	-217.54	18	-213.24	17		
-208.95	16	-188.81	15	-142.2	14	-124.64	13	-111.73	12		
-99.48	11	-90.14	10	-85.36	9	-75.22	8	-72.59	7		
-69.95	6	-67.31	5	-65.91	4	-64.82	3	-63.73	2		
-62.63	1	-61.51	0	-60.99	-1	-55.37	-2	-45.91	-3		
-42.07	-4	-39.39	-5	-34.4	-6	-29.74	-7	-26.9	-8		
-23.42	-9	-19.46	-10	-13.09	-11	-4.74	-12	0	-12.43		
1.5	-12	16.05	-11	16.61	-11	18.87	-10	21.14	-9		
23.4	-8	25.67	-7	27.93	-6	30.2	-5	33.17	-4		
34.8	-3	41.78	-2.11	53.53	-2	301.13	-1	307.67	-.82		
308.37	0	309.19	1.27	317.71	2	331.62	3	345.09	4		
346.88	5	347.88	5.75	348.92	6	351.47	6.49	352.14	7.61		
353.86	8	354.95	8.25								

Manning's n Values

Sta n Val			num= 5								
Sta	n Val	Sta	n Val	Sta	n Val	Sta	n Val	Sta	n Val	Sta	n Val
-229.74	.08	-65.91	.06	-55.37	.03	41.78	.03	331.62	.08		

Bank Sta: Left Right		Lengths: Left Channel			Right		Coeff	Contr.	Expan.
		31	31	31			.1	.3	
-55.37	41.78								

CROSS SECTION

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RIVER: BUNKER CREEK
REACH: Route 4

RS: 100

INPUT

Description:

Station	Elevation	Data	num=	59	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
-244.17	21.12	-236.17			20	-229.05		19	-221.92	18	-215.46	17
-211.21	16	-206.96			15	-191.29		14	-167.44	13	-146.68	13.58
-120.7	13	-108.98			12	-107.74		11	-106.5	10	-105.26	9
-104.02	8	-102.37			7	-100.24		6	-98.12	5	-95.74	4
-90.14	3	-83.45			2	-72.11		1	-67.02	0	-62.97	-1
-59.3	-2	-49.32			-3	-46		-4	-43.58	-5	-39.68	-6
-36.52	-7	-33.77			-8	-30.08		-9	-16.01	-9.85	-3.03	-9.34
0	-9.86	12.4			-9	16.36		-8	20.12	-7	23.81	-6
26.51	-5	29.2			-4	32.6		-3	46.82	-2	280.85	-1.09
281.73	.83	282.92			1	291.76		2	300.94	3	311.99	4
313.38	4.13	314.3			5	315.33		6	316.38	7	316.96	7.57
321.65	8	327.96			8.58	329.65		9	330.83	9.28		

Manning's n Values

Sta	n Val	Sta	num=	5	Sta	n Val	Sta	n Val	Sta	n Val	Sta	n Val
-244.17	.08	-83.45			.06	-59.3		.03	46.82	.03	291.76	.08

Bank Sta:	Left	Right	Lengths:	Left	Channel	Right	Coeff	Contr.	Expan.
	-59.3	46.82		38	38	38		.1	.3

CROSS SECTION

RIVER: BUNKER CREEK

REACH: Route 4

RS: 62

INPUT

Description: Confluence with Oyster River

Station	Elevation	Data	num=	51	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
-244.17	21.12	-236.17			20	-229.05		19	-221.92	18	-215.46	17
-211.21	16	-206.96			15	-191.29		14	-167.44	13	-146.68	13.58
-120.7	13	-108.98			12	-107.74		11	-106.5	10	-105.26	9
-104.02	8	-102.37			7	-100.24		6	-98.12	5	-95.74	4
-90.14	3	-83.45			2	-72.11		1	-67.02	0	-62.97	-1
-59.3	-2	-49.32			-3	-35		-4	-16.01	-4.3	-3.03	-4.4
0	-4.5	12.4			-4.4	16.36		-4.3	29.2	-4	32.6	-3
46.82	-2	280.85			-1.09	281.73		.83	282.92	1	291.76	2
300.94	3	311.99			4	313.38		4.13	314.3	5	315.33	6
316.38	7	316.96			7.57	321.65		8	327.96	8.58	329.65	9
330.83	9.28											

Manning's n Values

Sta	n Val	Sta	num=	5	Sta	n Val	Sta	n Val	Sta	n Val	Sta	n Val
-244.17	.08	-83.45			.06	-59.3		.03	46.82	.03	291.76	.08

Bank Sta:	Left	Right	Lengths:	Left	Channel	Right	Coeff	Contr.	Expan.
	-59.3	46.82		0	0	0		.1	.3

SUMMARY OF MANNING'S N VALUES

River:BUNKER CREEK

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n6	Reach	River Sta.	n1	n2	n3	n4	n5
Route 4		361	.08	.06	.035	.06	.08
Route 4		322	.08	.06	.035	.06	.08
Route 4		286	.08	.06	.035	.06	.08
Route 4		264	.08	.06	.035	.06	.08
Route 4		245	.08	.06	.035	.06	.08
Route 4		210	Bridge				
Route 4		184	.08	.06	.03	.03	.06
.08							
Route 4		162	.08	.06	.03	.03	.08
Route 4		131	.08	.06	.03	.03	.08
Route 4		100	.08	.06	.03	.03	.08
Route 4		62	.08	.06	.03	.03	.08

SUMMARY OF REACH LENGTHS

River: BUNKER CREEK

Reach	River Sta.	Left	Channel	Right
Route 4	361	39	39	39
Route 4	322	36	36	36
Route 4	286	22	22	22
Route 4	264	19	19	19
Route 4	245	61	61	61
Route 4	210	Bridge		
Route 4	184	22	22	22
Route 4	162	31	31	31
Route 4	131	31	31	31
Route 4	100	38	38	38
Route 4	62	0	0	0

SUMMARY OF CONTRACTION AND EXPANSION COEFFICIENTS

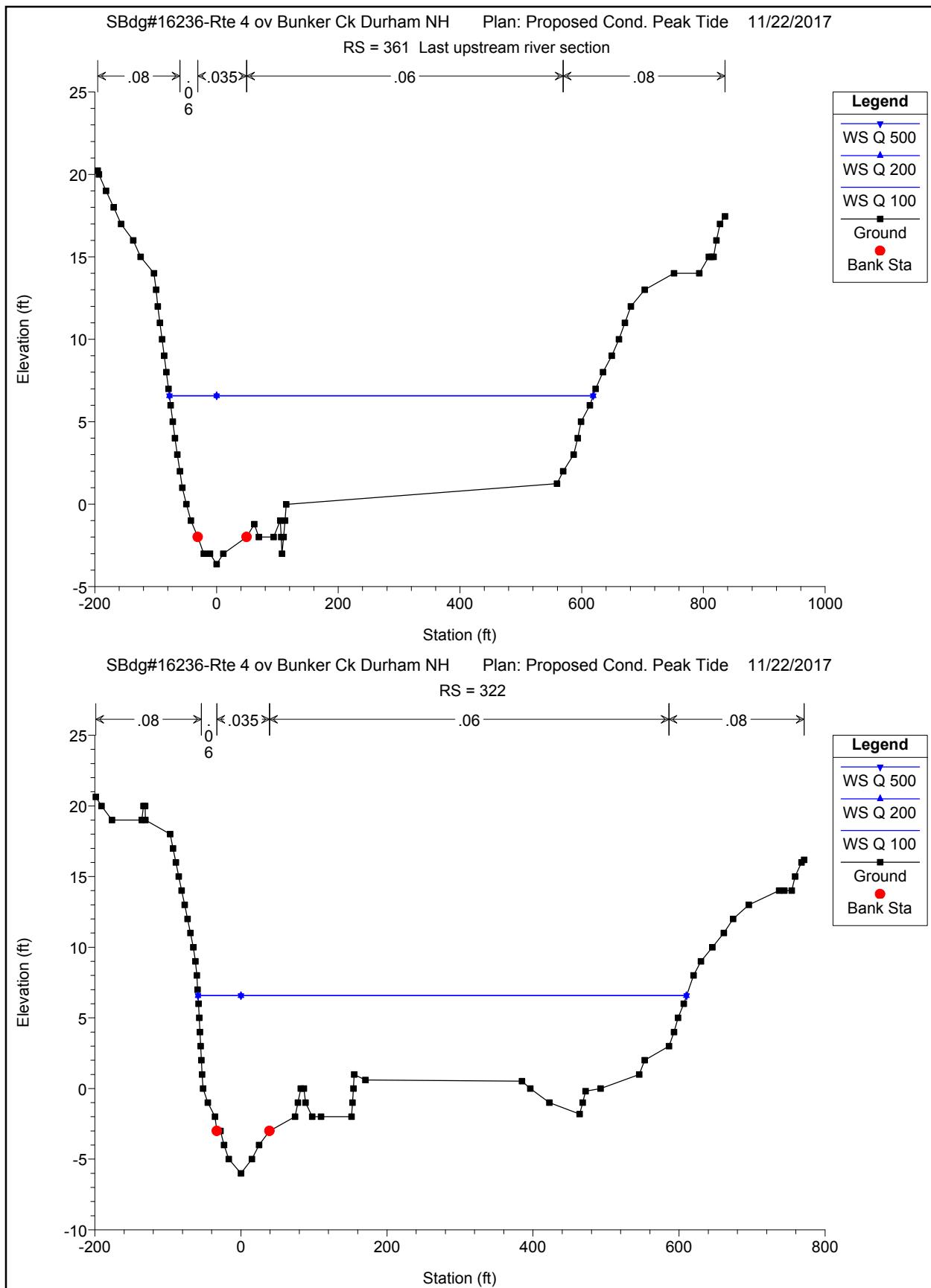
River: BUNKER CREEK

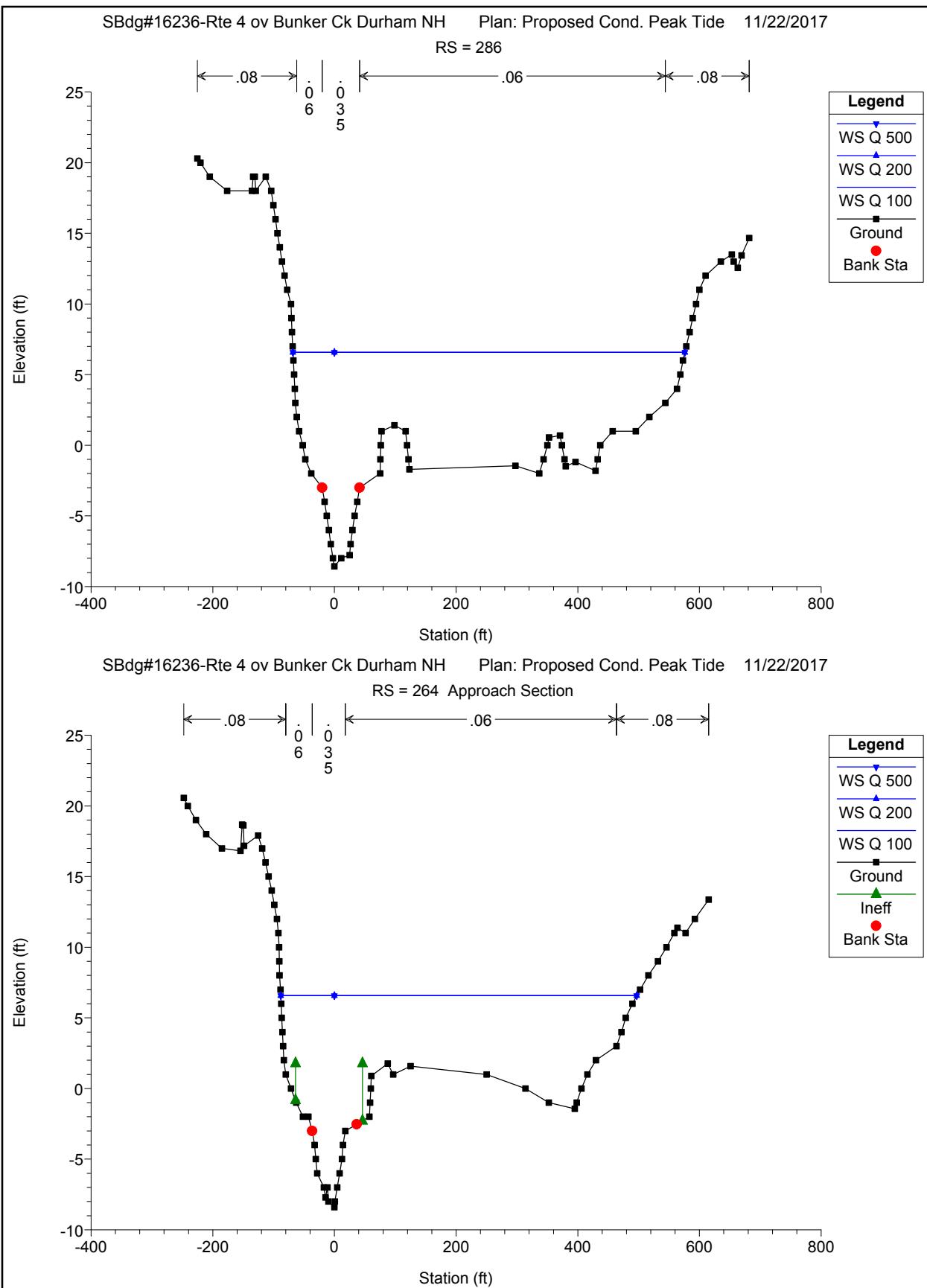
Reach	River Sta.	Contr.	Expan.
Route 4	361	.1	.3
Route 4	322	.1	.3
Route 4	286	.1	.3
Route 4	264	.3	.5

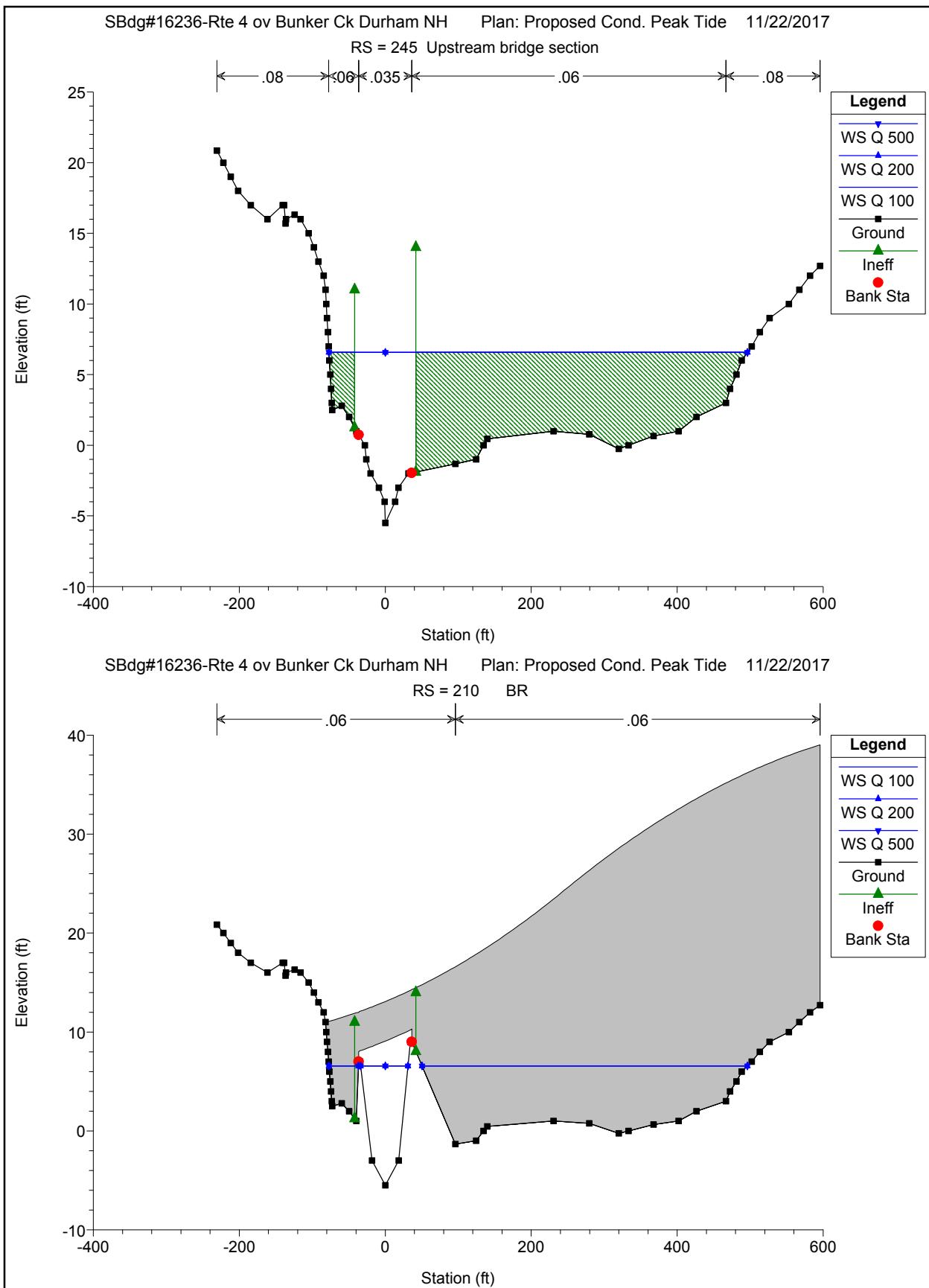
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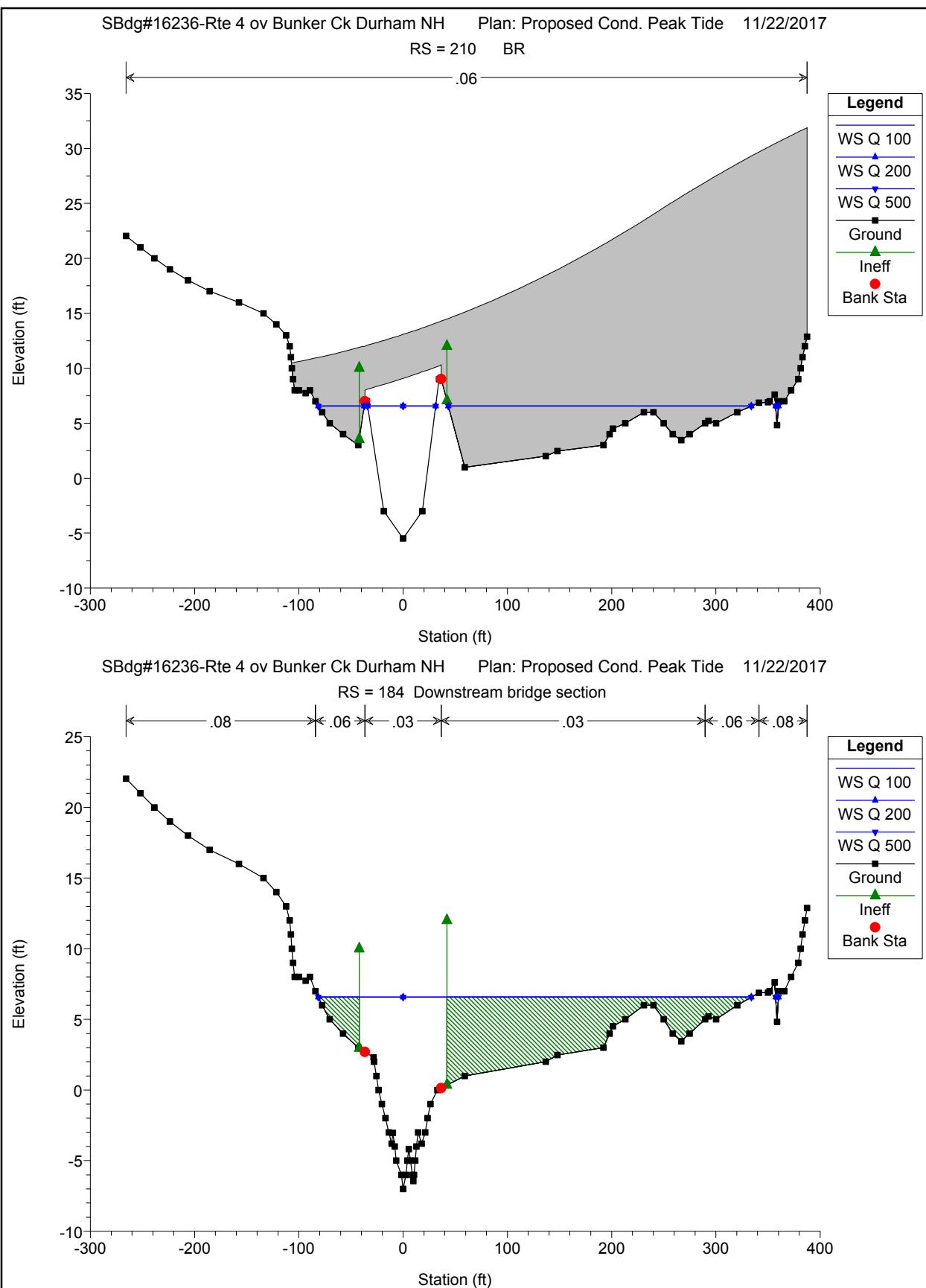
Route 4	245	.3	.5
Route 4	210	Bridge	
Route 4	184	.3	.5
Route 4	162	.1	.3
Route 4	131	.1	.3
Route 4	100	.1	.3
Route 4	62	.1	.3

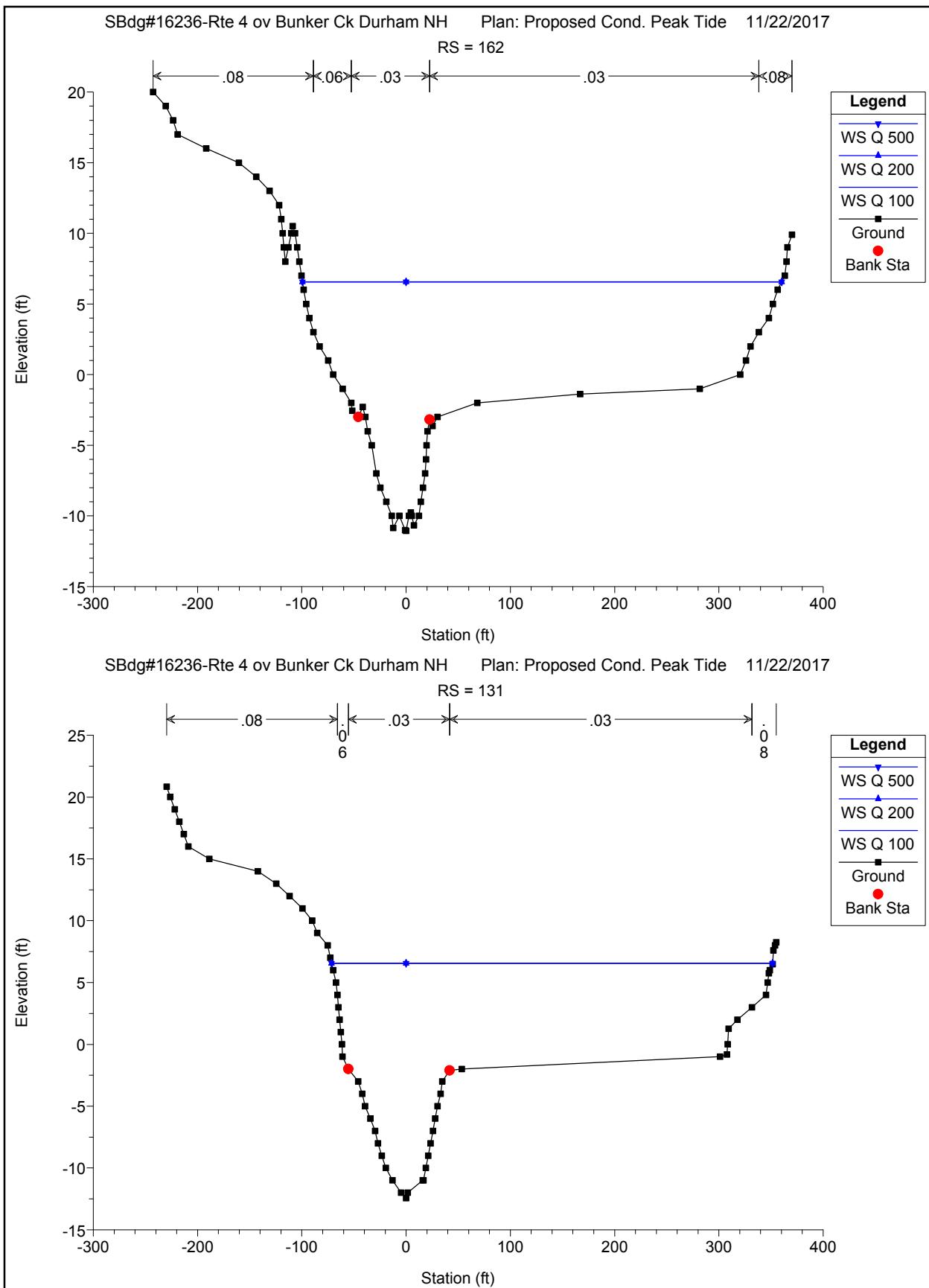
Cross Section Plots

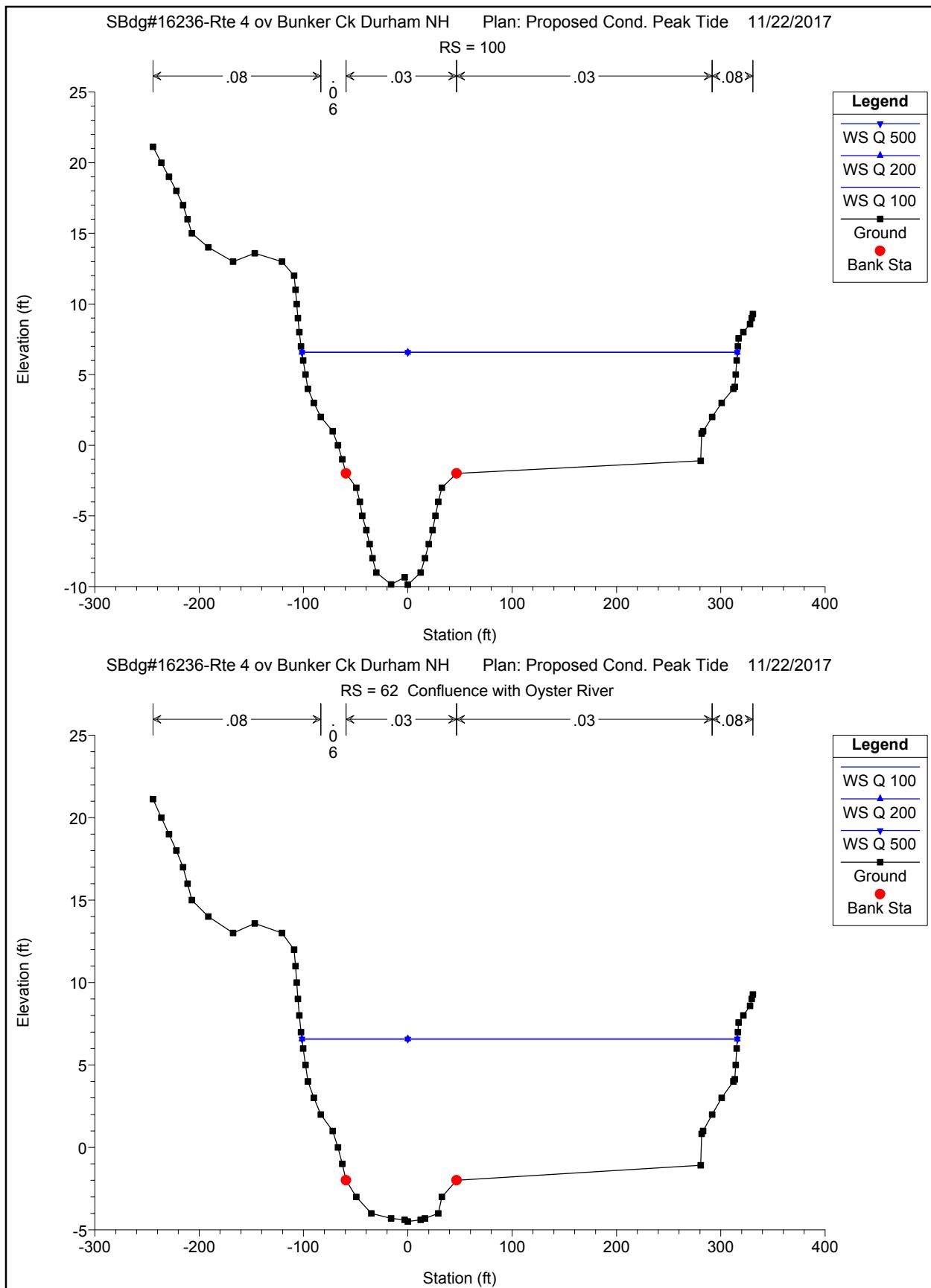


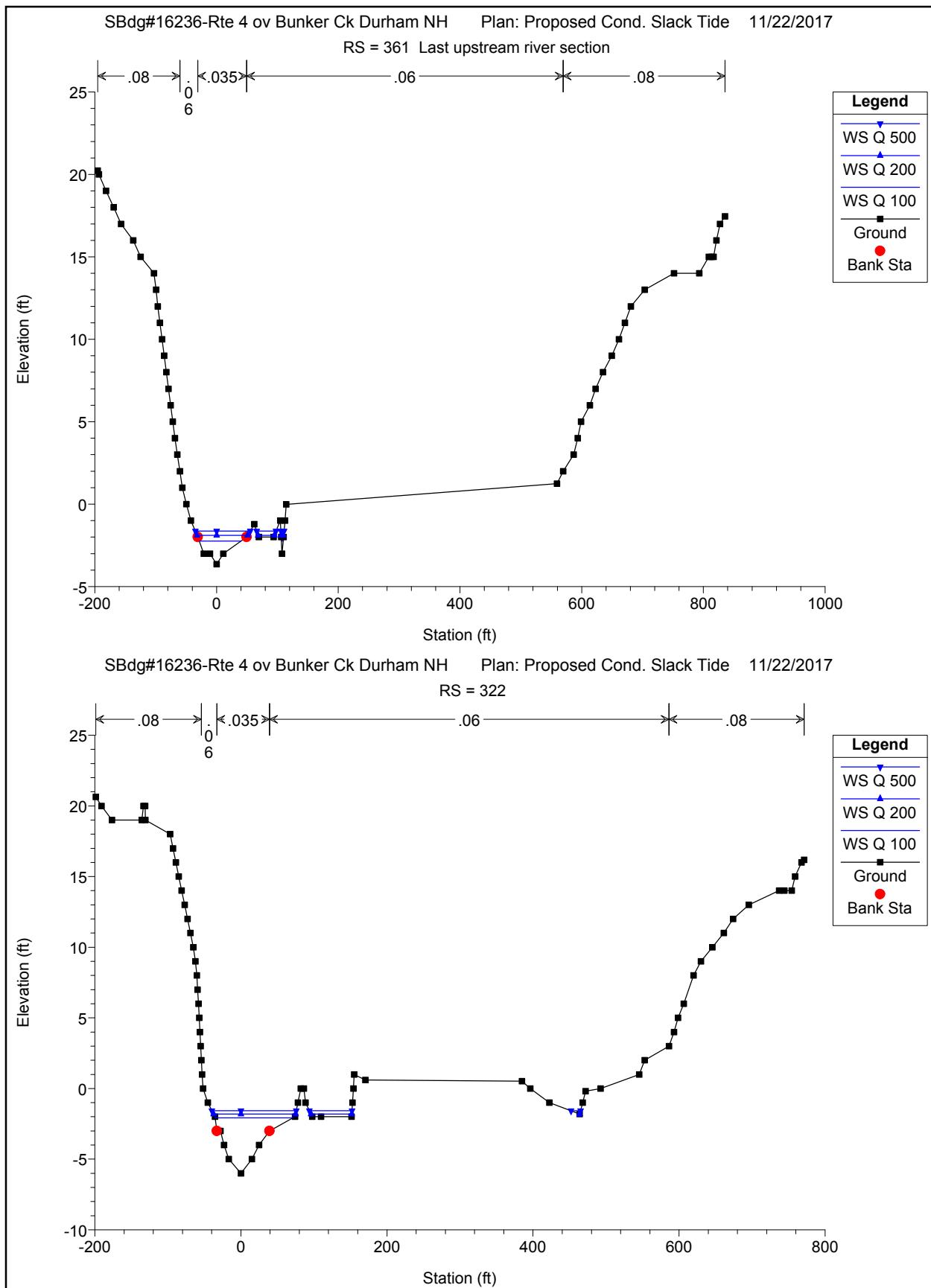


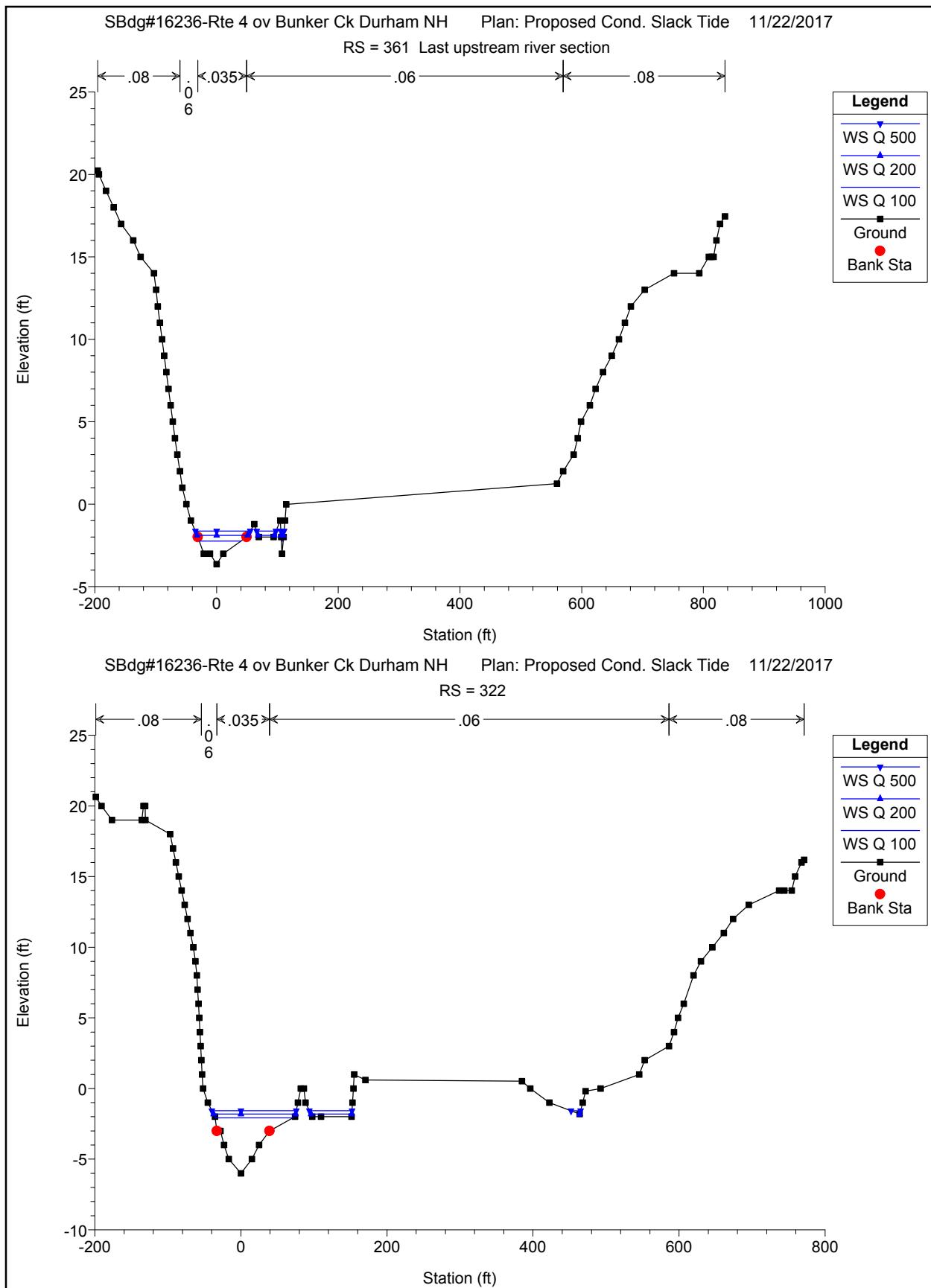


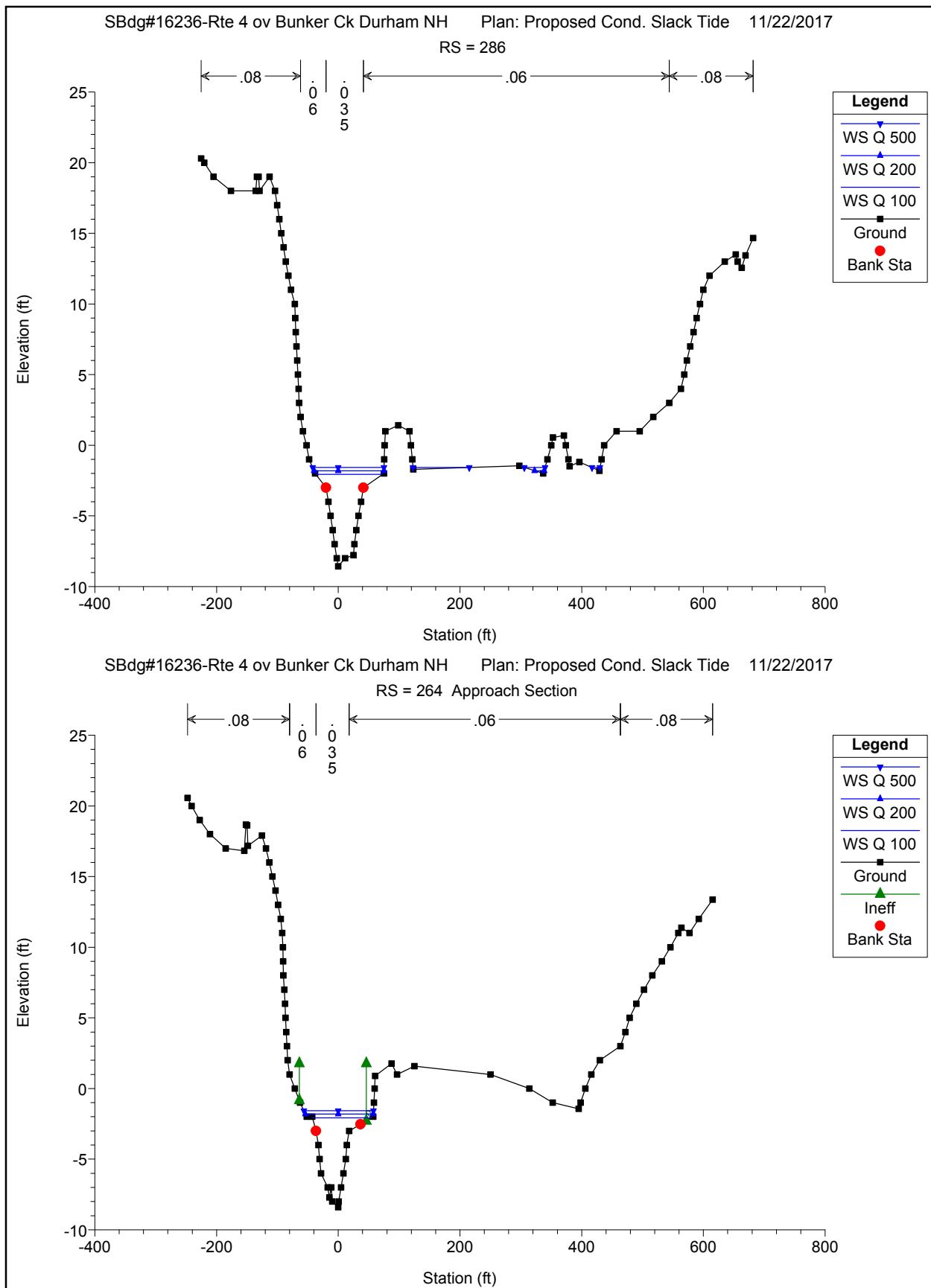


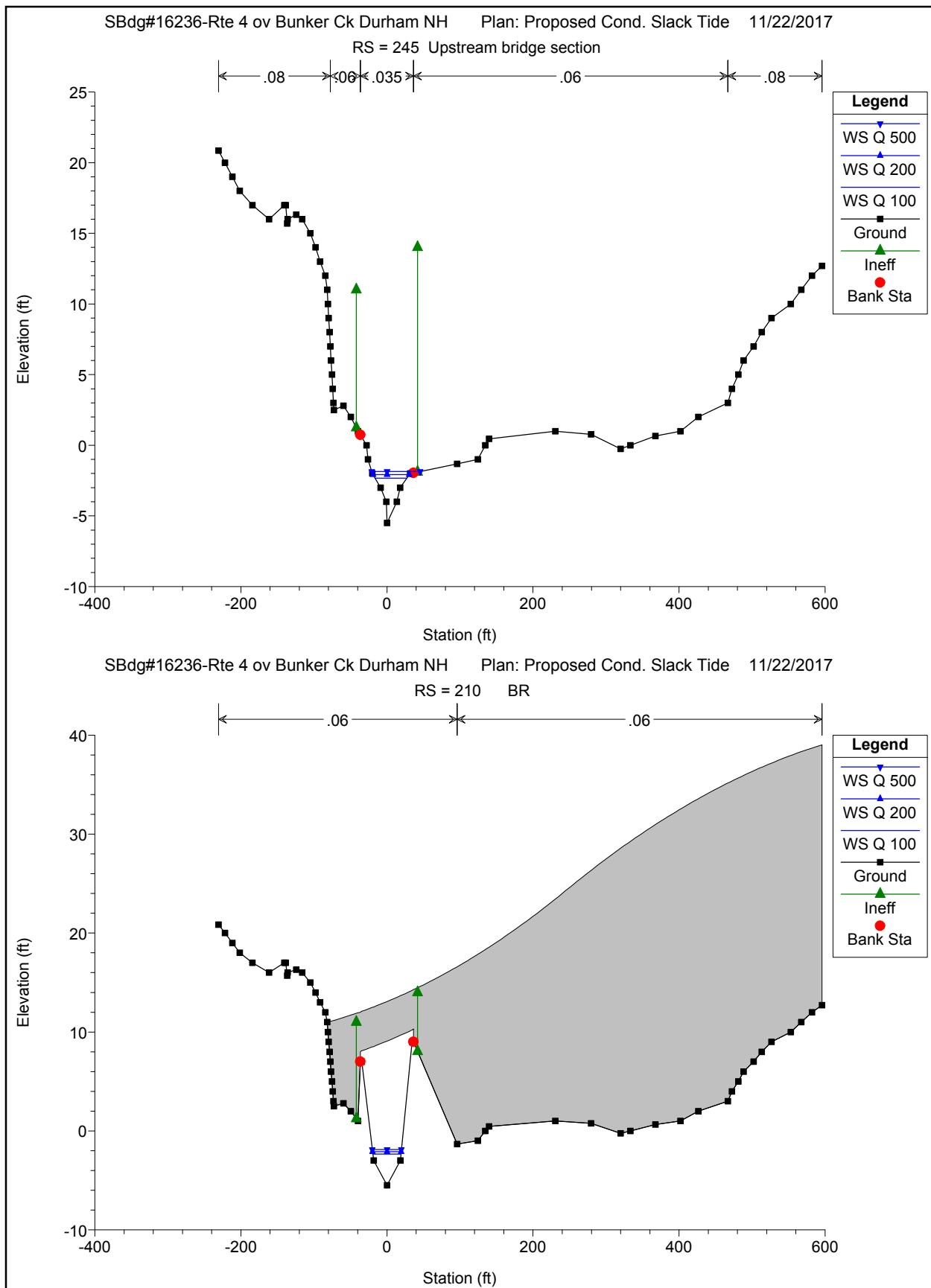


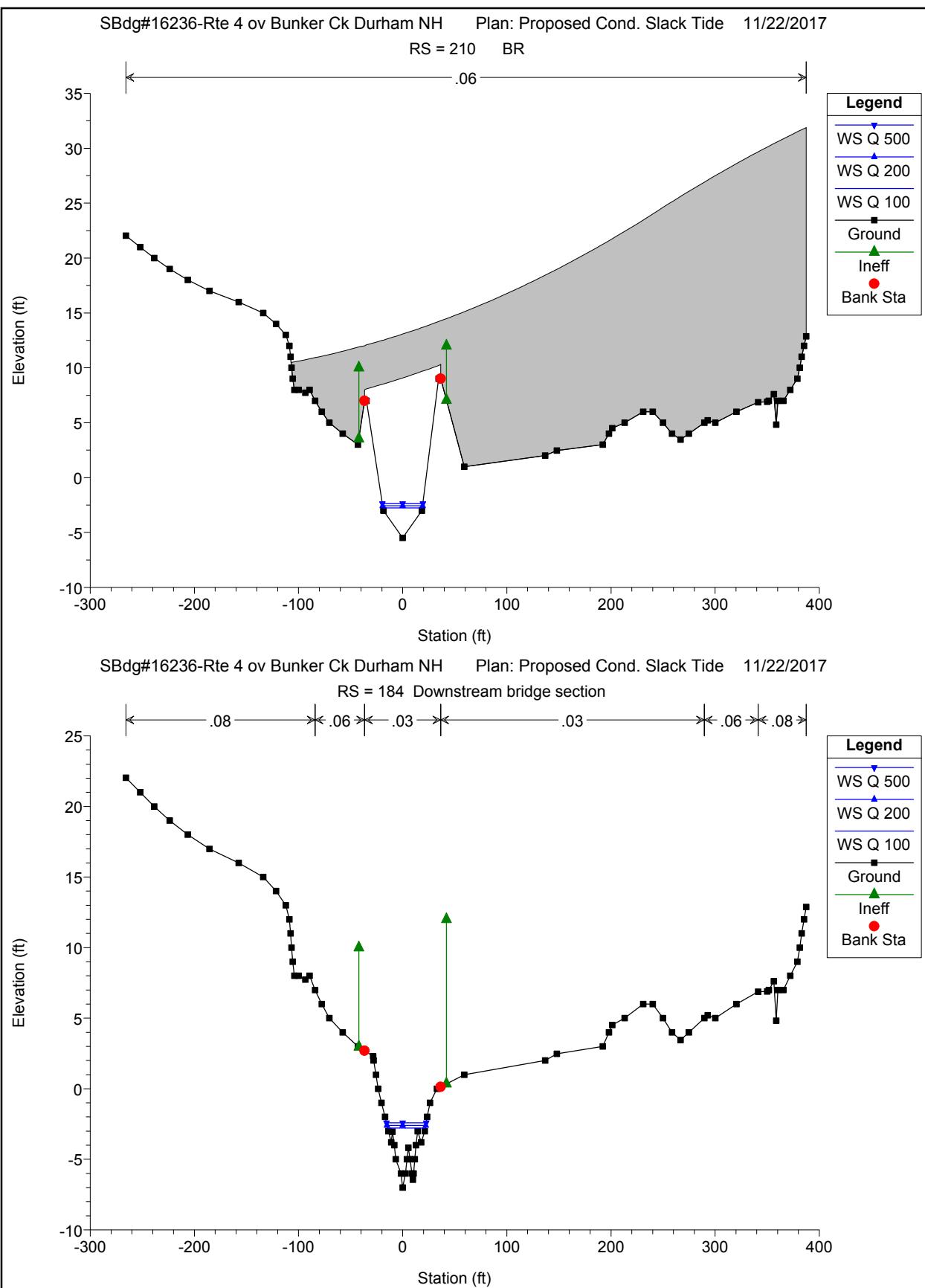


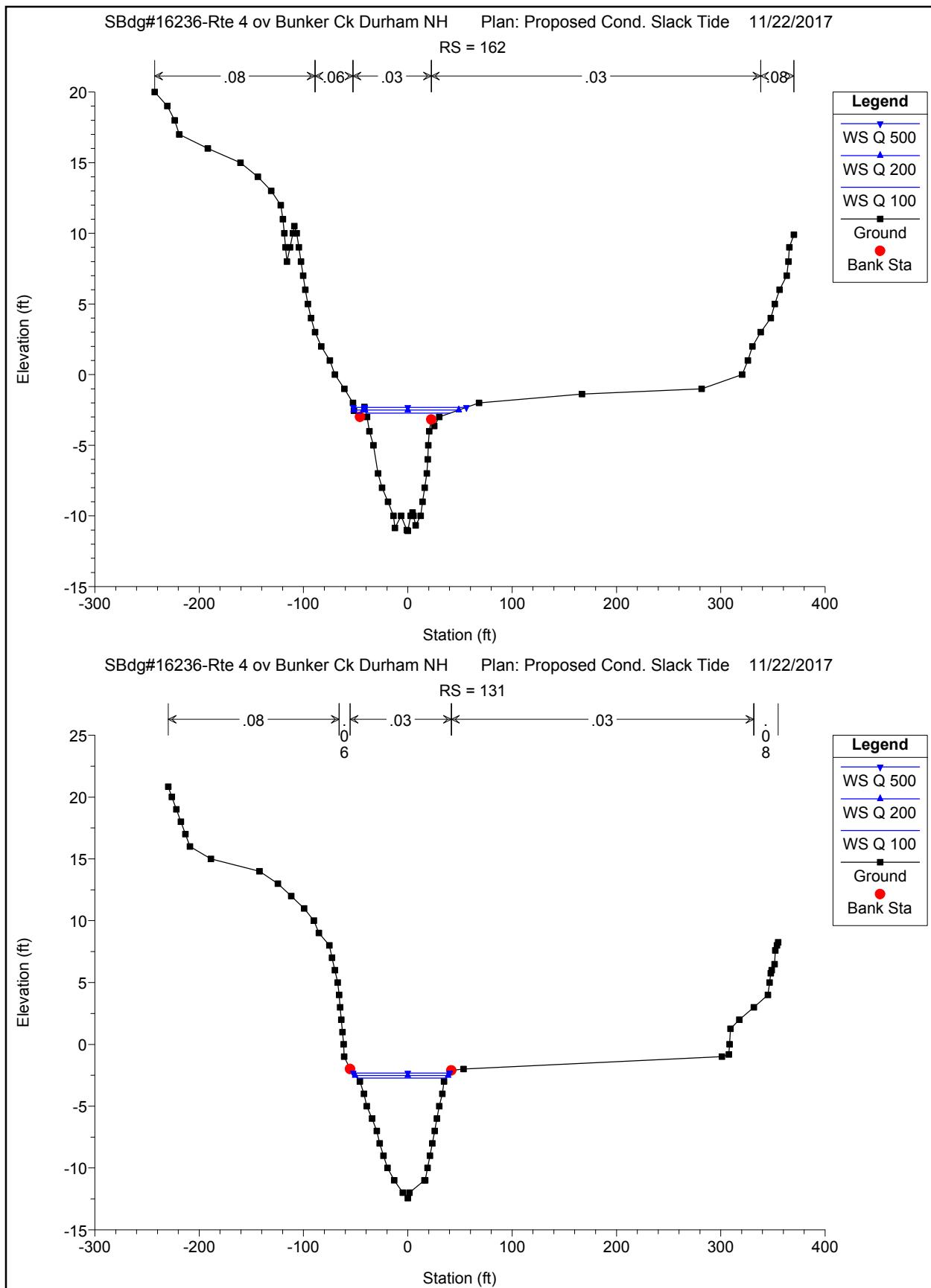


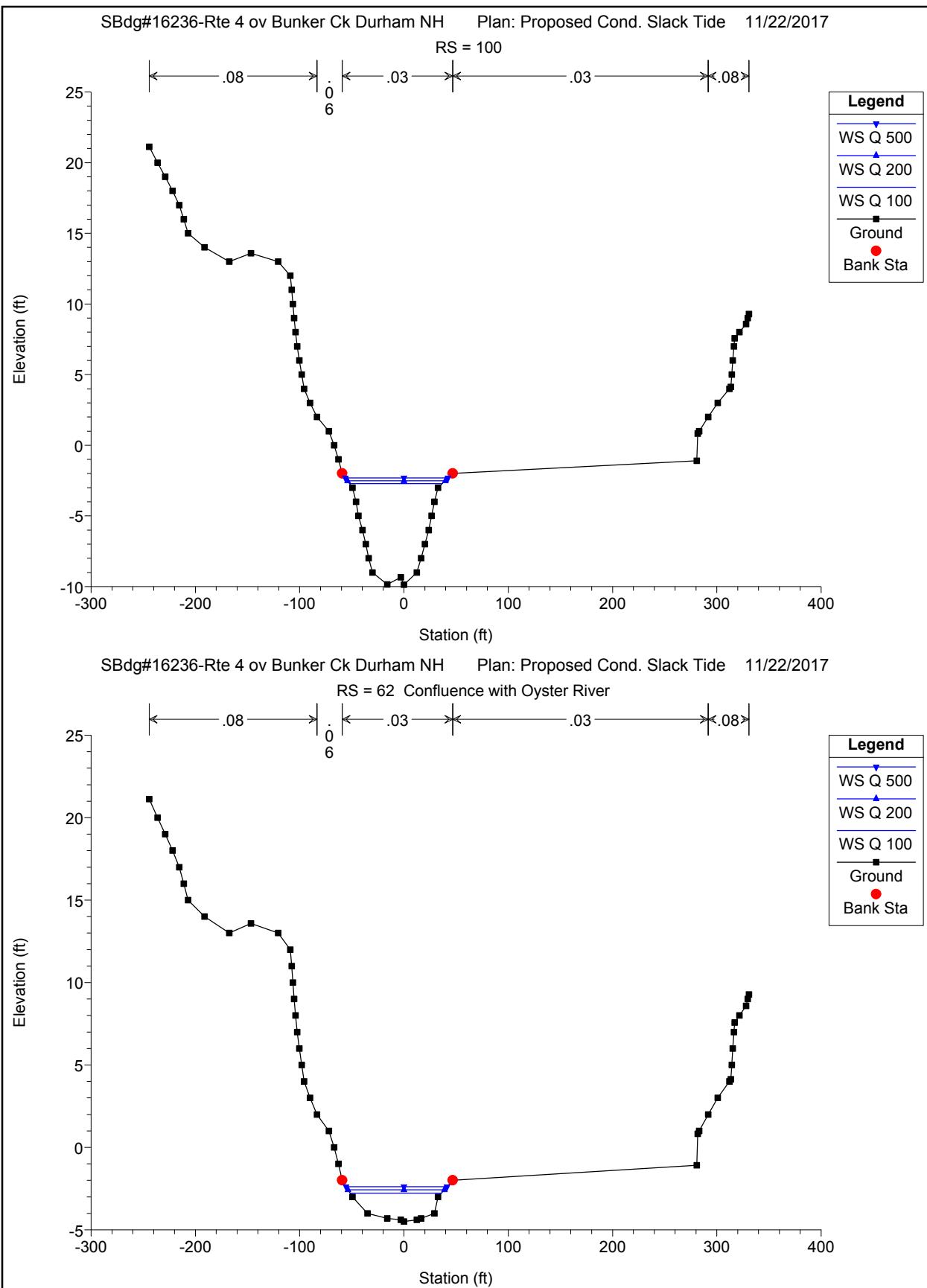


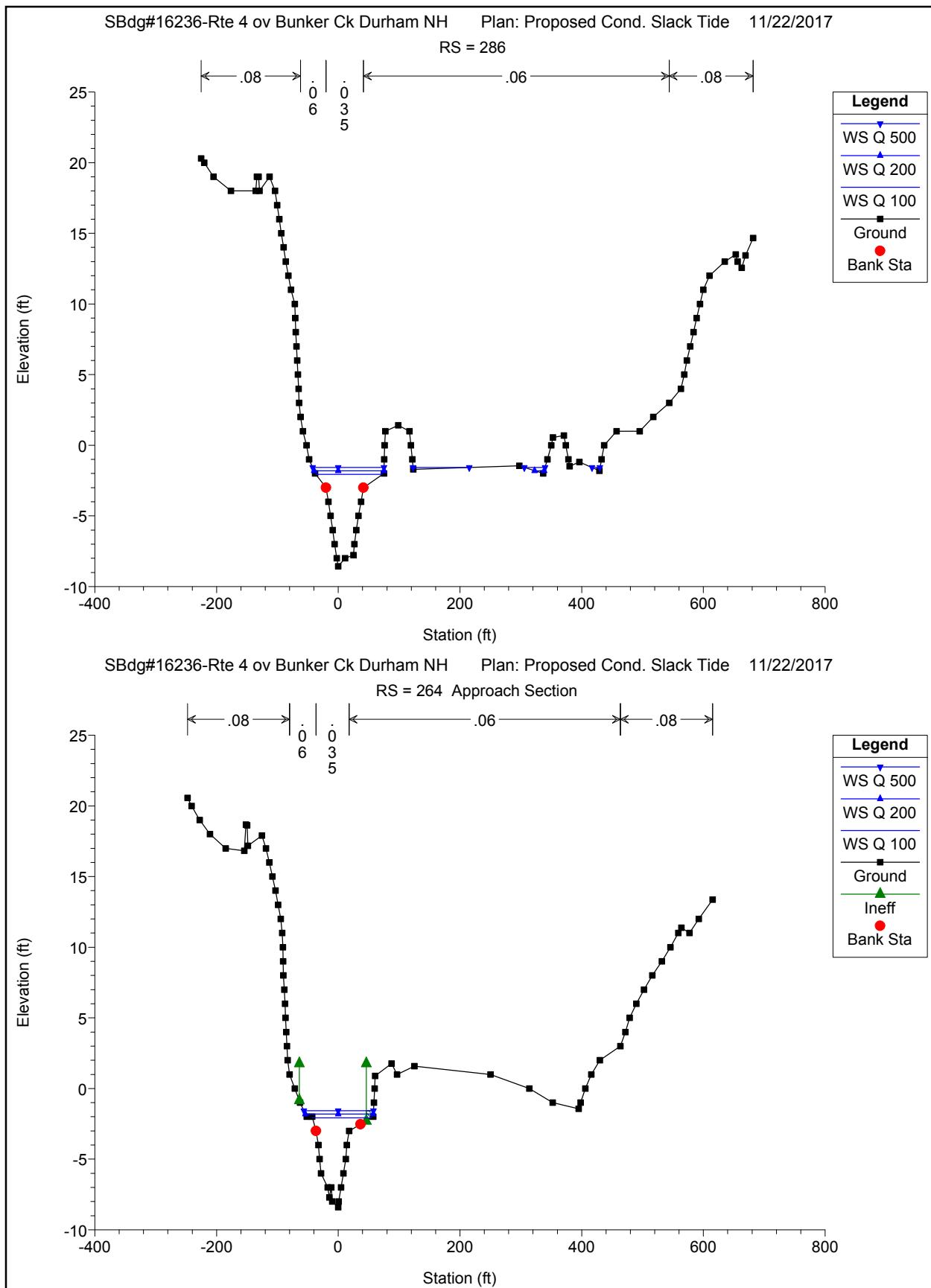


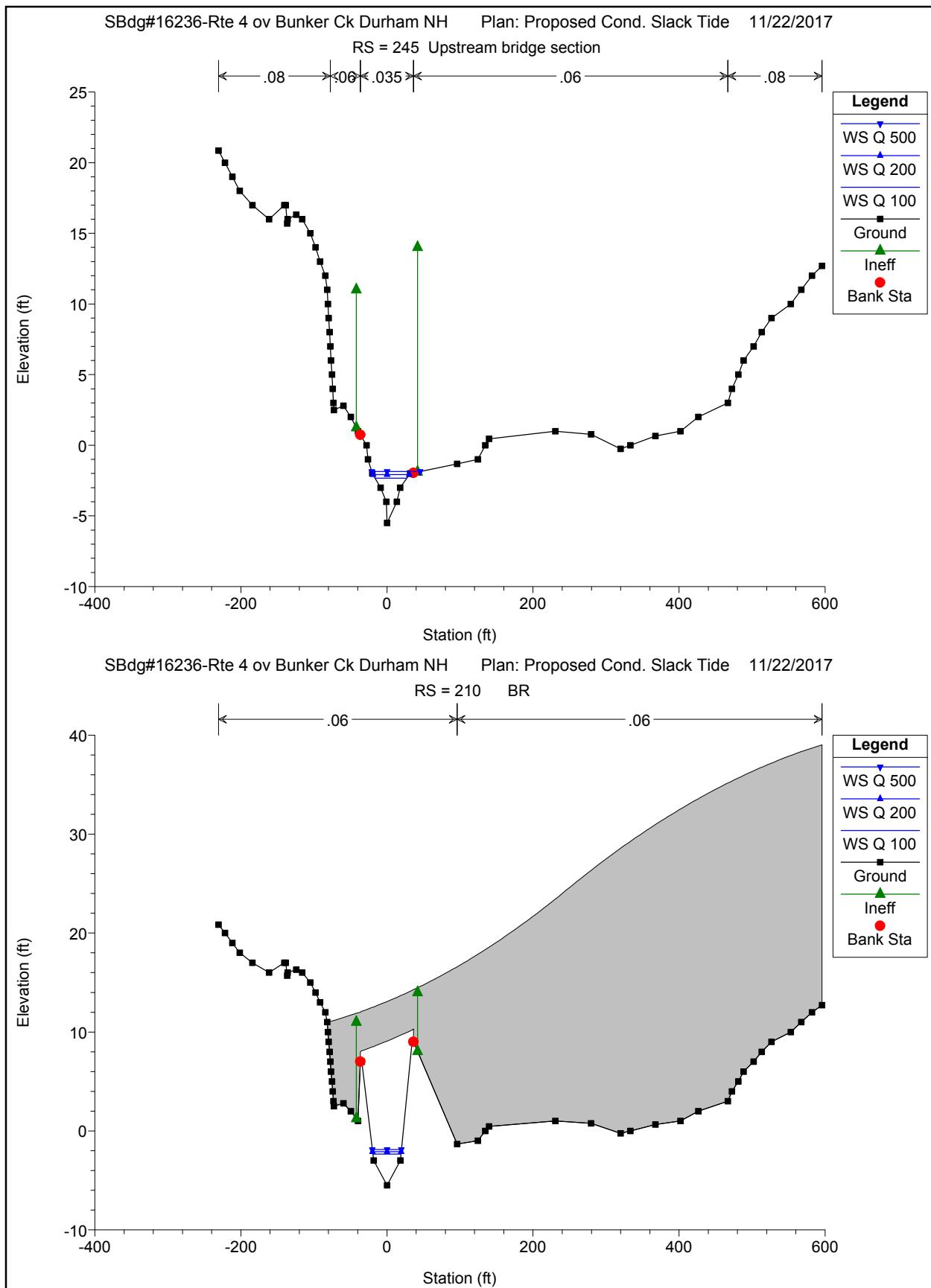


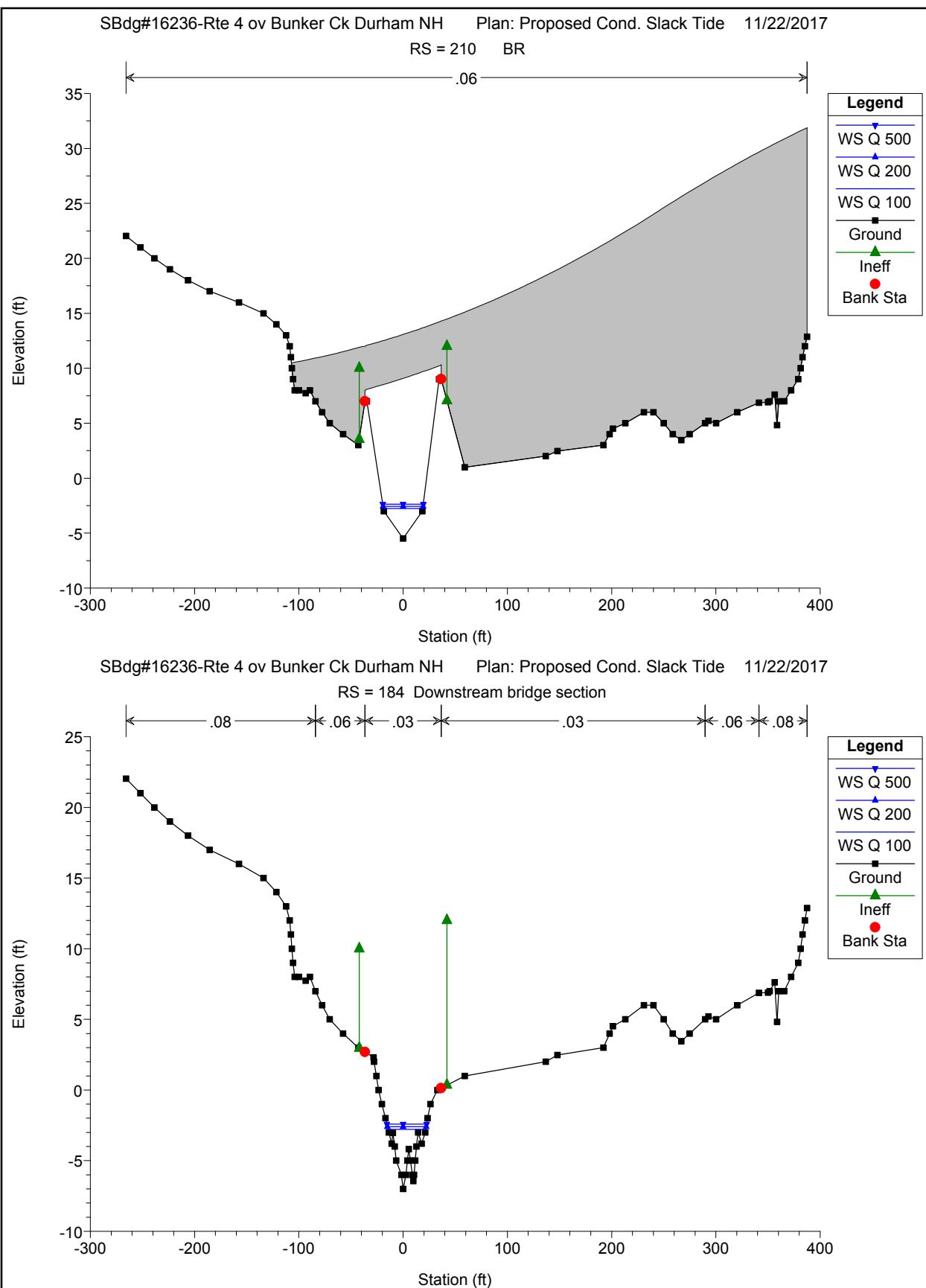


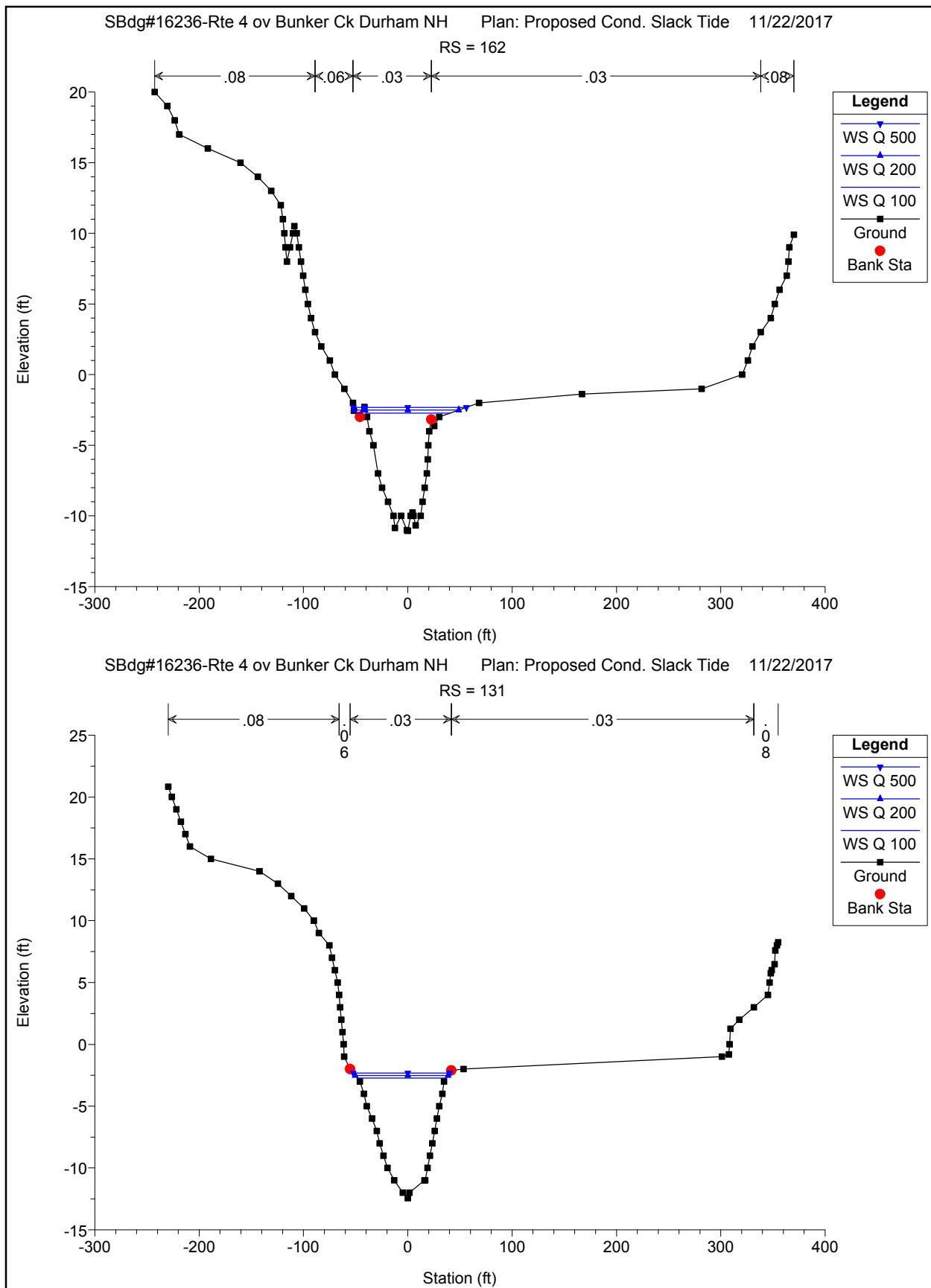


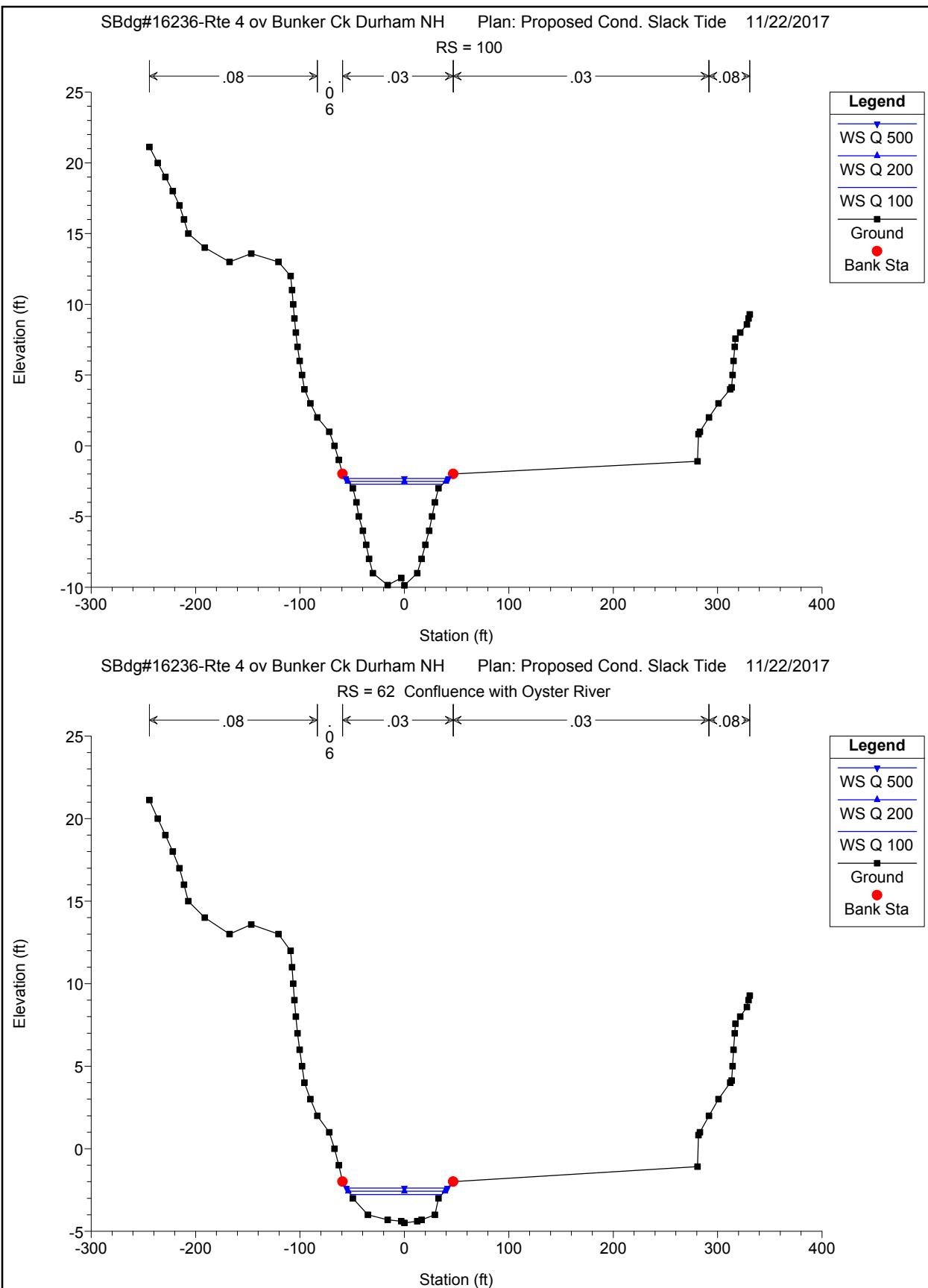












Appendix C

Scour Analysis Output

Critical Velocity Computation

Project: US Route 4 **Designed:** Richard T. Geikie **Date:** 20 Nov. 2017 **Units:** English

Location: Durham, NH **Bridge Type:** 73' Span Deck Unit Stub Abut. On Deep Foundation **Flow Event:** 200 year

General Scour Parameters:	D ₅₀ (ft)	0.0007	0.01 mm	Bridge Approach Section -	264
	(0.0007 ft. or 0.2 mm Minimum)				
		11.17			

Q=200-yr	Q=200-yr
Slack Tide	Peak Tide
Normal Depth	Storm Surge

Area of active flow upstream of the bridge, A	244.90	705.96
Top width of active flow upstream of the bridge, w _t	54.61	54.61
Average depth of flow upstream of the bridge, y	4.48	12.93
Mean Channel Velocity, V _{avg}	0.99	0.14
Critical velocity for incipient motion of bed material, V _c =K _u y ^{1/6} D ^{1/3}	1.27	1.52

Determine Clear Water Scour or Live Bed Scour

If V_c > V_{avg} => clear water

If V_c < V_{avg} => live bed

Therefore, material transport is.....

Clear Water	Clear Water
-------------	-------------

Clear Water Contraction

Project: US Route 4	Designed by: Richard T. Geikie	Date: 20 Nov. 2017	Units: English
Location: Durham, NH	Bridge Type:	73' Span Deck Unit Stub Abut. On Deep Foundation	Flow Event: 200 year
General Scour Parameters:	D ₅₀ #REF! 0.0007 (0.01 mm) (0.0007 ft. or 0.2 mm Minimum)	K _u = 0.0077	Bridge Approach Section - 264
			Q 200 Q 200 Slack Peak
Discharge through the bridge width (W), Q (cfs)		250.00 250.00	
Median Diameter of Bed Material, D ₅₀ (ft)		0.0007 0.0007	
Dia. of the smallest nontransportable particle in the bed material in the contracted section (1.25D ₅₀), (ft)		0.0009 0.0009	
Width of the contracted section less pier widths, W (ft)		39.00 65.00	
Average existing depth in the contracted section, y ₀ (ft)		2.04 8.17	
K _u , 0.0077 English Units		0.0077 0.0077	

Calculate Average Equilibrium Depth in the Contracted Section after Contraction Scour, y2

$$y2 = \frac{(Ku)(Q^2)}{(Dm^{2/3})(W^2)} ^{3/7}$$

Average equilibrium depth in the contracted section after contraction scour, y2..... 4.57 2.95

Calculate Average Contraction Scour Depth, ys

$$ys = y2 - y0$$

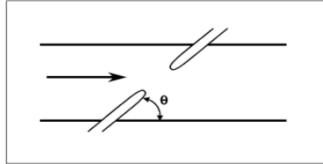
Average Contraction scour depth, ys..... 2.53 0.00

ABUTMENT SCOUR, as amended

Project: US Route 4 **Designed by:** Richard T. Geikie **Date:** 20 Nov. 2017 **Units:** English

Location: Durham, NH **Bridge Type:** 73' Span, Deck Unit w/ Stub Abut. on Deep Foundation **Flow Event:** 200 year

General Scour Parameters: D_{50} (m) (0.01 mm) **Bridge Approach Section** 264



$\theta > 90$ if embankment points upstream

$\theta < 90$ if embankment points downstream

Coefficient for abutment shape, K_1

Table 7.1. Abutment Shape Coefficients.	
Description	K_1
Vertical-wall abutment	1.00
Vertical-wall abutment with wing walls	0.82
Spill-through abutment	0.55

Coefficient for angle of embankment to flow, $K_2 = (\theta/90)^{0.13}$

		Q200 Slack Tide		Q200 Storm Surge	
		Left	Right	Left	Right
Q-100	Q-500	0.55	0.55	0.55	0.55

Left $\theta =$	<input type="text" value="90.00"/>	<input type="text" value="90.00"/>	<input type="text" value="1.00"/>	<input type="text" value="1.00"/>	<input type="text" value="1.00"/>	<input type="text" value="1.00"/>
Right $\theta =$	<input type="text" value="90.00"/>	<input type="text" value="90.00"/>				

From HEC-RAS stream tube upstream from abutment tip:

Flow obstructed by the abutment and approach embankment, Q_e

	0.65	0.85	19.75	134.36
(fps)	0.11	0.15	0.06	0.06
(ft)	0.35	0.60	8.79	8.98
(ft)	0.04	0.09	0.53	0.54
(ft)	16.88	9.44	37.45	249.37

Length of active flow obstructed by embankment, L'

(ft)	17.32	20.90	51.45	460.21
(sq ft)	6.10	5.56	361.83	2598.89
(fps)	0.11	0.15	0.05	0.05
(ft)	0.35	0.27	7.03	5.65
(ft)	0.03	0.05	0.00	0.00

Unit Discharge in tube at abutment tip, q_t

(ft)	0.04	0.09	0.53	0.54
(ft)	16.88	9.44	37.45	249.37
(ft)	17.32	20.90	51.45	460.21
(sq ft)	6.10	5.56	361.83	2598.89
(fps)	0.11	0.15	0.05	0.05

Average depth of flow on the floodplain, $y_a = A_e/L$

(ft)	0.35	0.27	7.03	5.65
(ft)	0.03	0.05	0.00	0.00
(ft)	16.88	9.44	37.45	249.37
(sq ft)	6.10	5.56	361.83	2598.89
(fps)	0.11	0.15	0.05	0.05

Froude Number of approach flow upstream of the abutment, $Fr = V_e / (g * y_a)^{1/2}$

(ft)	16.88	9.44	37.45	249.37
(ft)	17.32	20.90	51.45	460.21
(sq ft)	6.10	5.56	361.83	2598.89
(fps)	0.11	0.15	0.05	0.05
(ft)	0.35	0.27	7.03	5.65

Length of embankment projected normal to the effective flow field, L'

(ft)	16.88	9.44	37.45	249.37
(ft)	17.32	20.90	51.45	460.21
(sq ft)	6.10	5.56	361.83	2598.89
(fps)	0.11	0.15	0.05	0.05
(ft)	0.35	0.27	7.03	5.65

Scour depth, $y_s = Y_a - 2.27 K_1 K_2 \left(\frac{L'}{Y_a} \right)^{0.43} Fr^{0.61} + 0.05$

(ft)	0.30	0.27	0.94	1.49
(ft)	16.88	9.44	37.45	249.37
(sq ft)	6.10	5.56	361.83	2598.89
(fps)	0.11	0.15	0.05	0.05
(ft)	0.35	0.27	7.03	5.65